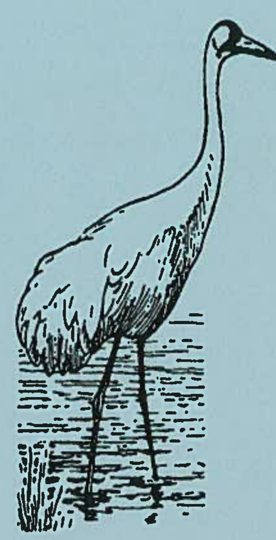
U.S. FISH & WILDLIFE SERVICE
REGION 6
CONTAINANTS PROGRAM

A COMPREHENSIVE ANALYSIS AND INTERPRETATION OF CONTAMINANT DATA FROM THE SAN LUIS VALLEY, COLORADO 1986 - 1989

by

Andrew L. Thompson and Richard P. Krueger



U.S. Fish and Wildlife Service
Fish and Wildlife Enhancement
Western Colorado Sub-Office

November 1990

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NOVEMBER 1990

U.S FISH AND WILDLIFE SERVICE
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WESTERN COLORADO SUB-OFFICE

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Abstract
The San Luis Valley was chosen as a contaminant study site under the U.S. Fish and Wildlife Service's (Service) Region 6 "Hot Spot" study program in 1987. The Service "Hot Spot" studies were designed to monitor certain areas for contaminants in fish and wildlife. These "Hot Spots" are of significant biological importance and were selected with regard to environmental and geological factors that create potential contaminant problems for fish and wildlife. In many cases, previous information has suggested the possibility of a contaminant problem.

Geologically speaking, the northern half of the San Luis Valley is a "closed basin" system that contains and accumulates all of the water that enters the northern portion of the valley. As a result, this closed basin has a valuable ground water supply in the form of both confined and unconfined aquifers (U.S. Geological Survey, 1989). A network of irrigation and drainage ditches provides some of this water to other areas of the valley. With a variety of water sources, especially from the surrounding mountains, the valley's water supply could potentially accumulate environmental contaminants as it enters the valley and is stored in this unique hydrologic system. If present, these contaminants could be trapped in the valley, become available to fish and wildlife, and possibly endanger the ground-water supply.

Results of this study identify three major stream drainages that are apparently being directly impacted by past and present mining activity in the area. These streams are Willow Creek, Kerber Creek, and Wightman Fork. Biota, water, and sediment samples from these areas and downstream sites contain high concentrations of metals including aluminum, cadmium, copper, lead, mercury, and zinc. In addition, liver samples from great blue herons found dead on Monte Vista National Wildlife Refuge contained high concentrations of mercury and selenium.

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Introduction

In the San Luis Valley, Colorado, there is a great potential for the accumulation of environmental contaminants, particularly heavy metals. If present, environmental contaminants could be exposed to the abundance of wildlife that resides in the valley and its surrounding areas. Biota, water, and sediment samples were screened for a variety of inorganic trace elements or organochlorine pesticides (Table 1). Possible sources of these inorganic trace elements and organochlorines include mine tailings, run-off from headwater streams in the surrounding mountains, intensive agriculture, and various commercial enterprises. The analytical results presented in this report are compared to a variety of guidelines and baseline information.

The principle area of concern in the valley is the Alamosa/Monte Vista National Wildlife Refuge. This National Wildlife Refuge (NWR) is considered one of the most valuable areas to migratory birds and endangered species among the federal refuges in Colorado.

The data presented in this report were derived from samples collected during 1986-1989. Initial sampling in 1986 was implemented as part of a whooping crane habitat contaminant study (James Lewis, pers. comm.). Based partly on this baseline information, the San Luis Valley Hot Spot Study was initiated in 1987. Two major sampling efforts were completed in 1987, one during the summer and the other in the fall. Subsequent collections involved a variety of samples taken at different locations within the valley. Several preliminary reports have been written summarizing individual sample groups. Information from these earlier reports has been incorporated into this report.

Sampling efforts were aided by personnel from the U. S. Fish and Wildlife Service, the Colorado Division of Wildlife, the U. S. Bureau of Reclamation, and the Colorado Cooperative Fish and Wildlife Research Unit (CO-OP) at Colorado State University. This report will be supplemented by an additional study being conducted by the CO-OP unit.

Objectives

The purpose of this study was to determine if the aquatic systems and associated wildlife in the San Luis Valley are being exposed to potentially harmful levels of environmental contaminants. In addition, the identification of possible contaminant bioaccumulation between different biological trophic levels and the identification of potential "hot spot" areas were also objectives of this study.

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Description of Study Area

The San Luis Valley lies in the Rio Grande Basin which is located in south-central Colorado and contains the headwaters of the Rio Grande River and its tributaries (Figure 1). It should be noted that throughout this report sampling sites are referenced by site name and number. The reader is asked to refer to figure 1 to reference the location of any sites in question. The Rio Grande Basin is bounded by the San Juan Mountains on the west and the Sangre de Cristo range on the east. These two mountain ranges meet to the north and form a northern boundary. The southern boundary, which extends into New Mexico, is relatively undefined. The valley is situated longitudinally in the Rio Grande Basin and is approximately 120 miles long, 50 miles wide, and encompasses about 3200 square miles (U. S. Geological Survey, 1989).

The topography and geology of the San Luis Valley are that of an asymmetric trough. This large, faulted trough has been filled over time with interbedded fine- to coarse-grained alluvial and lacustrine deposits, volcanic flows, and volcaniclastic rocks (U.S. Geological Survey, 1989). These valley-fill deposits are estimated to be as much as 19,000 feet thick (Burroughs, 1981).

The San Luis Valley is a high mountain valley with an arid to semiarid climate and is characterized by low levels of precipitation, mild temperatures, and abundant sunshine. Alamosa, Colorado, which is in the approximate center of the valley, had an average annual precipitation of 7.13 inches for the years 1951-80 (National Oceanic and Atmospheric Administration, 1951-80). The dry climate combined with moderate southwesterly winds facilitated the formation of sand dunes in Great Sand Dunes National Monument in the north-eastern part of the valley.

The economy of the valley is based predominantly on agriculture, as evidenced by the many farms and small communities. A variety of crops are grown including wheat, barley, alfalfa, potatoes, and onions (Alamosa Chamber of Commerce, pers. comm.). Large spray-type irrigation systems are common as are row-crop irrigation systems. Much of the water used for irrigation is ground-water withdrawn through flowing wells from unconfined aquifers in the closed basin; irrigation water is also diverted from the Rio Grande River.

Hydrologic Setting

The San Luis Valley may be subdivided into two major areas of surface water drainage, or subbasins: (1) The contributing drainage of the Rio Grande River; and (2) the Closed Basin, an area of internal drainage that is north of the Rio Grande (U.S. Geological Survey, 1989). These areas are separated by a low drainage divide (see subbasin boundary, Figure 1) that extends from the western side of the valley near Del Norte, south-east to a

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point about 8 miles east of Alamosa, then north-east towards the edge of the valley near Blanca (U.S. Geological Survey, 1989).

The contributing drainage area to the Closed Basin is mainly from the mountains to the north and west via Saguache and San Luis Creeks (figure 1). The Sangre de Cristo Mountains to the east also provide several smaller stream drainages. The aquifers of the Closed Basin are re-charged mainly by surface water percolating down through the valley fill deposits (U.S. Geological Survey, 1989). Sources of surface water to the basin are both the contributing stream drainages and irrigation return flows. In addition to infiltration of surface water, underflow from volcanic rocks of the San Juan Mountains and precipitation are sources of ground water re-charge to the confined and unconfined aquifers of the Closed Basin (U.S. Geological Survey, 1989).

Fish and Wildlife Resources

The Alamosa/Monte Vista NWR complex (Figure 2) is the most valuable wildlife resource area in the San Luis Valley. The refuge complex consists of two separate tracts of land that are often referred to individually. However, both the Alamosa tract and the Monte Vista tract are managed under a single headquarters office near Alamosa.

The refuge complex is an important area for nesting and migrating waterfowl as well as an important wintering area for bald and golden eagles and a variety of other raptors. During the spring and fall migrations, thousands of sandhill cranes use the refuge as a resting, feeding and staging area. Whooping cranes are also often observed during this time. The whooping crane population that migrates through the valley was started as an experimental population in 1975 and is known as the Gray's Lake Flock. This flock breeds at Grays Lake NWR near Soda Springs, Idaho, then flies south to winter at Basque del Apache NWR in central New Mexico.

Encompassing a total of 37 square miles (16 at Alamosa and 21 at Monte Vista), the refuge complex supports as much as 15,500 acres of wetland habitat (Steve Berlinger, pers. comm.). Each year 10,000-15,000 waterfowl nest on the refuge, with as many as 75,000 ducks and geese utilizing the area during the spring and fall migrations (Steve Berlinger, pers. comm.). The refuge complex also has excellent upland habitat that provides winter range for deer and elk as well as habitat for many species of small mammals.

There are four State Wildlife Areas that occur within the study area: (1) Russel Lakes; (2) San Luis Lakes; (3) Rio Grande; and (4) Hot Creek. These public lands are managed by the Colorado Division of Wildlife (Division) and provide valuable fish and wildlife resource areas to the valley.

Russel Lakes Waterfowl Management Area (WMA) is located approximately 8 miles south of Saguache, Colorado. The U.S. Bureau of

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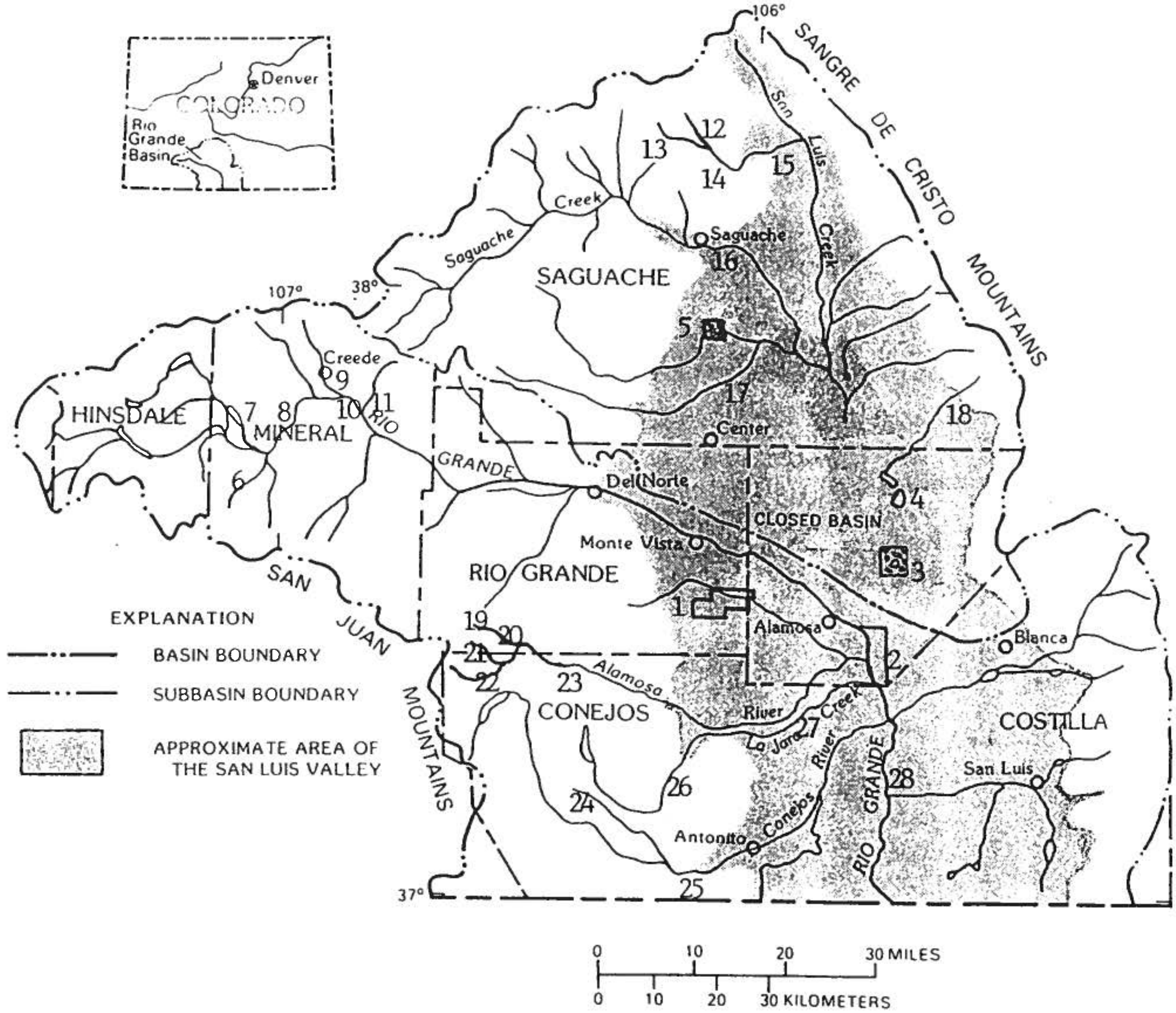


Figure 1.* Location of the San Luis Valley in the Rio Grande Basin.

SITE NAMES

1. Monte Vista NWR
2. Alamosa NWR
3. Dry Lakes
4. San Luis Lakes SWA
5. Russel Lakes WMA
6. Fern Cr.
7. Seepage Cr.
8. Marshall Park (Rio Grande R.)
9. Willow Cr.
10. Wason Ranch (Rio Grand R.)
11. Bellows Cr.
12. Kerber Cr. #1
13. Slaughterhouse Cr.
14. Kerber Cr. #2
15. Kerber Cr. #3
16. Saguache Cr.
17. La Garita Cr.
18. Indian Springs
19. U. Wightman Fork
20. L. Wightman Fork
21. Bitter Cr.
22. U. Alamosa R.
23. L. Alamosa R.
24. U. Conejos R.
25. L. Conejos R.
26. U. La Jara Cr.
27. L. La Jara Cr.
28. La Bota Bridge (Rio Grande R.)

*Adapted from U.S. Geological Survey, 1989.

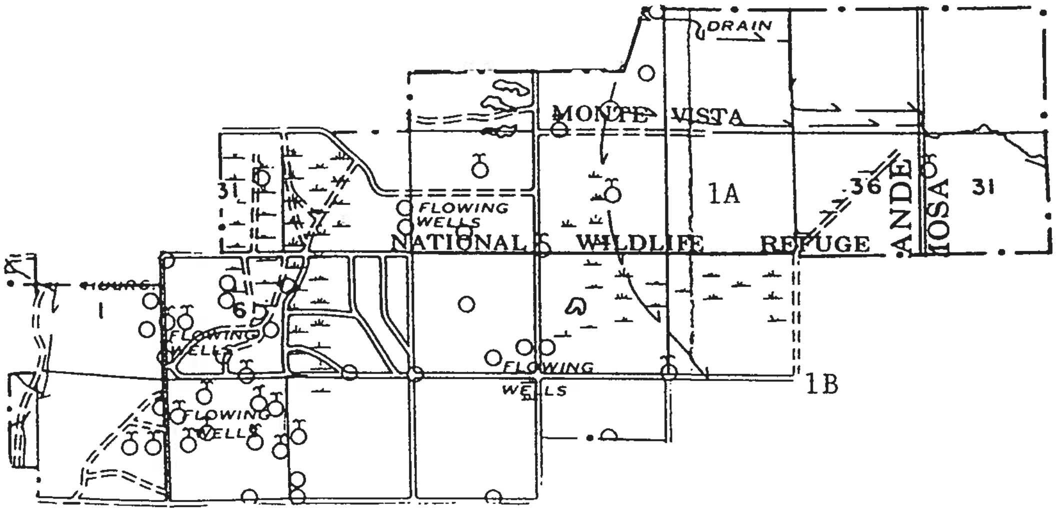
Reclamation recently acquired the area outlined in Figure 3 and is negotiating to acquire additional wetland areas adjacent to this tract. When completed, the Bureau will have obtained a total of 4600 acres which will be managed primarily for waterfowl habitat by the Division in conjunction with the State Wildlife Area (SWA). The large complex of lakes, ponds, and wetlands provides nesting habitat for waterfowl and shorebirds as well as feeding and resting areas for migrating ducks and geese.

San Luis Lakes SWA (Figure 4), located about 22 miles north-east of Alamosa, consists of two large lakes, San Luis Lake and Head Lake, and several smaller lakes totaling 315 surface acres. San Luis and Head are two of the larger lakes in the study area and are important resting and feeding areas for migrating waterfowl. The surrounding 2054 acres of land provide upland habitat for a variety of small mammals and birds. San Luis Lake is periodically stocked with rainbow trout by the Division, which provides intermittent recreational fishing opportunities. Typically, these fish grow very large in a short period of time before they apparently die, or otherwise disappear. The disappearance of the San Luis Lake fishery has not been explained; thus far there is no evidence to indicate a contaminant problem.

Rio Grande SWA is located three miles east of Monte Vista and includes approximately 1450 acres of mixed cottonwood forests and marshes along a four mile stretch of the Rio Grande River. The area provides ideal habitat for nesting waterfowl, upland game and wintering birds. A variety of migratory birds utilize the area including sandhill cranes and bald and golden eagles. The Rio Grande River and its numerous oxbow lakes hold warmwater game fish such as channel catfish, largemouth bass and northern pike.

Hot Creek SWA, 25 miles south of Monte Vista, is located on the western edge of the San Luis Valley along Hot Creek, a spring fed tributary of the Rio Grande River. The combination of 3500 acres of Division land and 9000 acres of Bureau of Land Management land is cooperatively managed by the two agencies primarily for deer and elk, in addition some waterfowl and upland game habitat is also available. Rainbow trout inhabit both Hot Creek and Poso Creek, also on the wildlife area.

Another important fish and wildlife resource area in the valley is the Bureau of Land Management's Blanca Wildlife Habitat Area, also known as Dry Lakes, which is located 10 miles northeast of Alamosa (Figure 5). The area is managed for waterfowl and small game habitat and encompasses approximately seven square miles. There are many small lakes and ponds on this property which vary in size and number depending upon the amount of snow melt each spring. Many of the more permanent ponds are filled from artesian wells and are stocked with fish species such as largemouth bass and rainbow trout.



1A. Monte Vista NWR
1B. Bowen Drain
2A. Alamosa NWR
2B. Rio Grande R.-Alamosa NWR

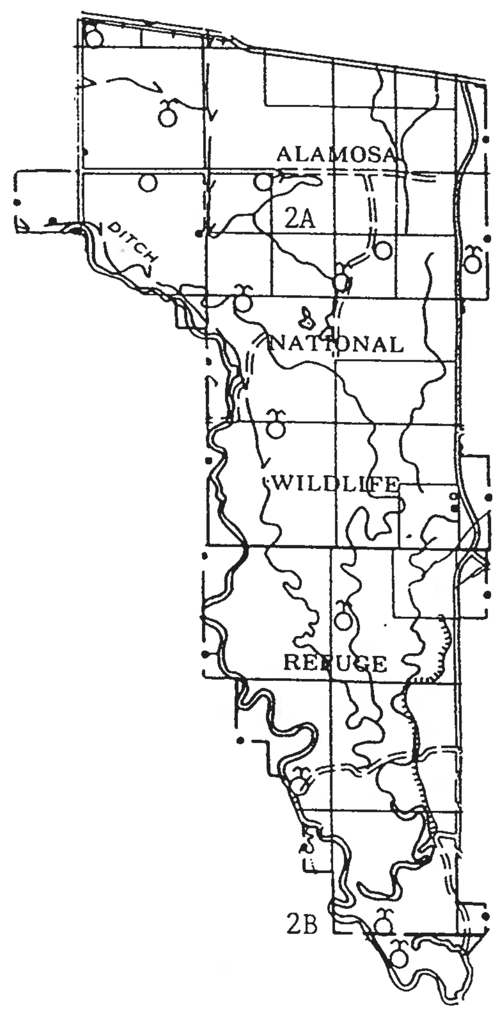


Figure 2. Alamosa/Monte Vista National Wildlife Refuge.

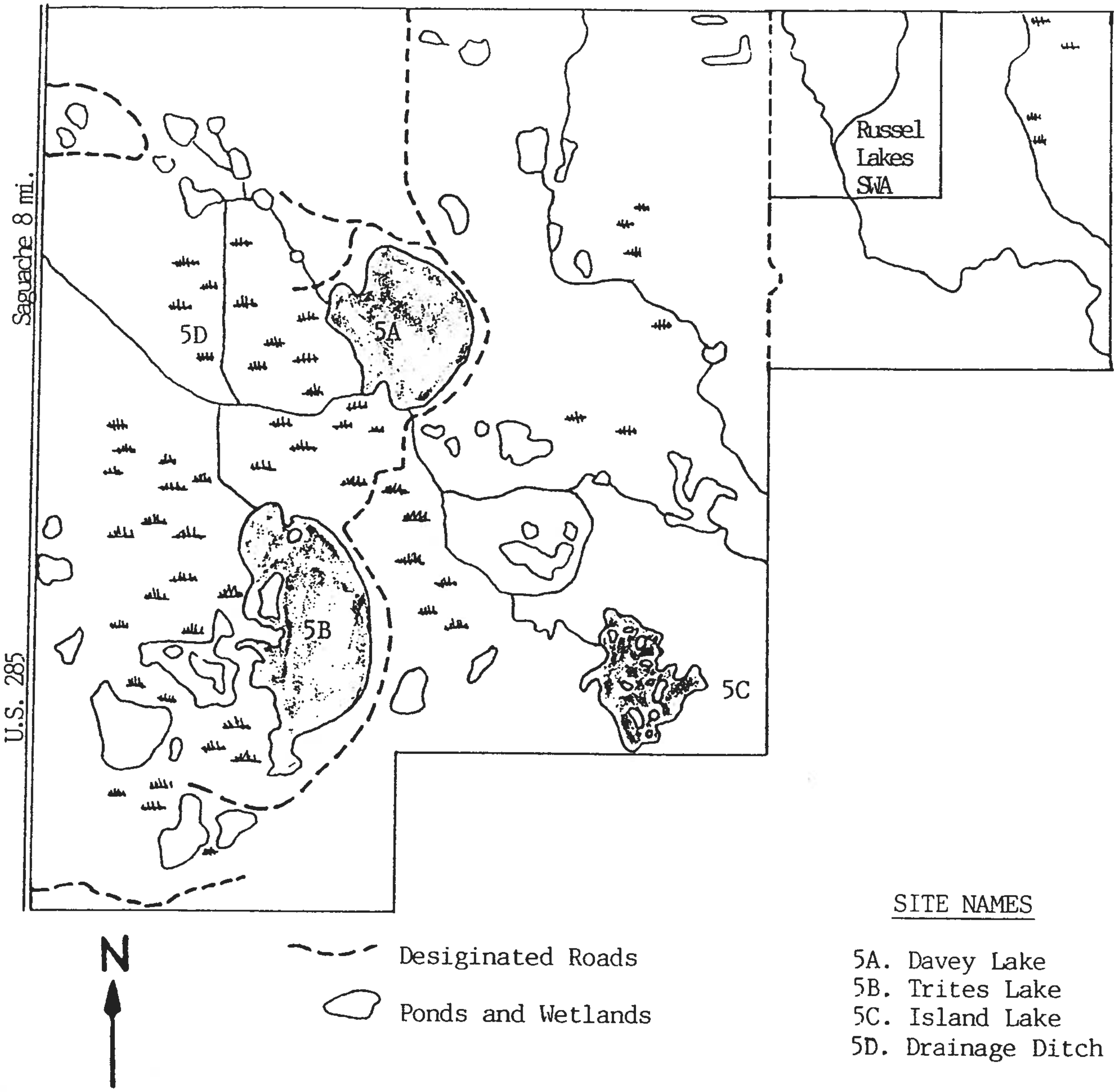


Figure 3. Russel Lakes Waterfowl Management Area. Managed by CDOW in conjunction with Russel Lakes State Wildlife Area (SWA).

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The San Luis Valley and it's many wildlife resource areas play an important role in the reproduction and migrations of a variety of migratory bird species. The area is rich with many different species of waterfowl, raptors, and shorebirds. Some unique species seen here include canvasbacks, white-faced ibis, snowy egrets, black-crowned night herons, and sandhill cranes. Three federally endangered migratory birds, the bald eagle, whooping crane, and peregrine falcon are also frequently observed. Bald eagles are usually abundant during the winter months while whooping cranes are often seen migrating with sandhill cranes in the spring and fall. Peregrine falcons are sometimes observed migrating through the valley and can be found nesting in the nearby mountain canyons. Other endangered species are not known to inhabit the valley, however, there is one rare plant, the slender spiderflower (Cleome multicaulis), that grows in many wet areas of the Closed Basin. This species is a category 2 candidate for listing as endangered.

Sample Collections

In order to identify specific "hot spots" or any possible bioaccumulation pathways between different trophic levels, an attempt was made to collect representative samples from the different trophic levels at each site. Biota selected from lower trophic levels (plants, invertebrates, and small forage fish) represent possible food sources for larger fish or bird species likely to be present in the study area. To make these types of determinations, consistency in species composition of samples among sites is necessary. However, this consistency could not always be achieved because of habitat variability and insufficient numbers of organisms.

Previous contaminant sampling conducted in the valley by the Service was initiated as part of a whooping crane habitat contaminant study on the Alamosa/Monte Vista NWR in August, 1986. This study, conducted by James C. Lewis (Whooping Crane Coordinator, Region 2), was designed to assess contaminant impacts to whooping crane habitat on their nesting, migrating, and wintering grounds. Samples were also collected at Grays Lake NWR in Idaho (whooping crane nesting grounds) and Basque Del Apache NWR in New Mexico (whooping crane wintering area). Unfortunately, this study was never completed due to the loss of the Grays Lake samples (James Lewis, pers. comm.). Samples collected for this study include sediment, pondweed, carp (whole body), and American coot (whole body).

The Service's San Luis Valley Hot Spot Study was begun in 1987 by the Grand Junction field office. The original study plan called for three major groups of samples to be collected during different time periods at three locations in the valley. The first two of these were accomplished as planned; however, the third group of samples could not be collected due to budget constraints.

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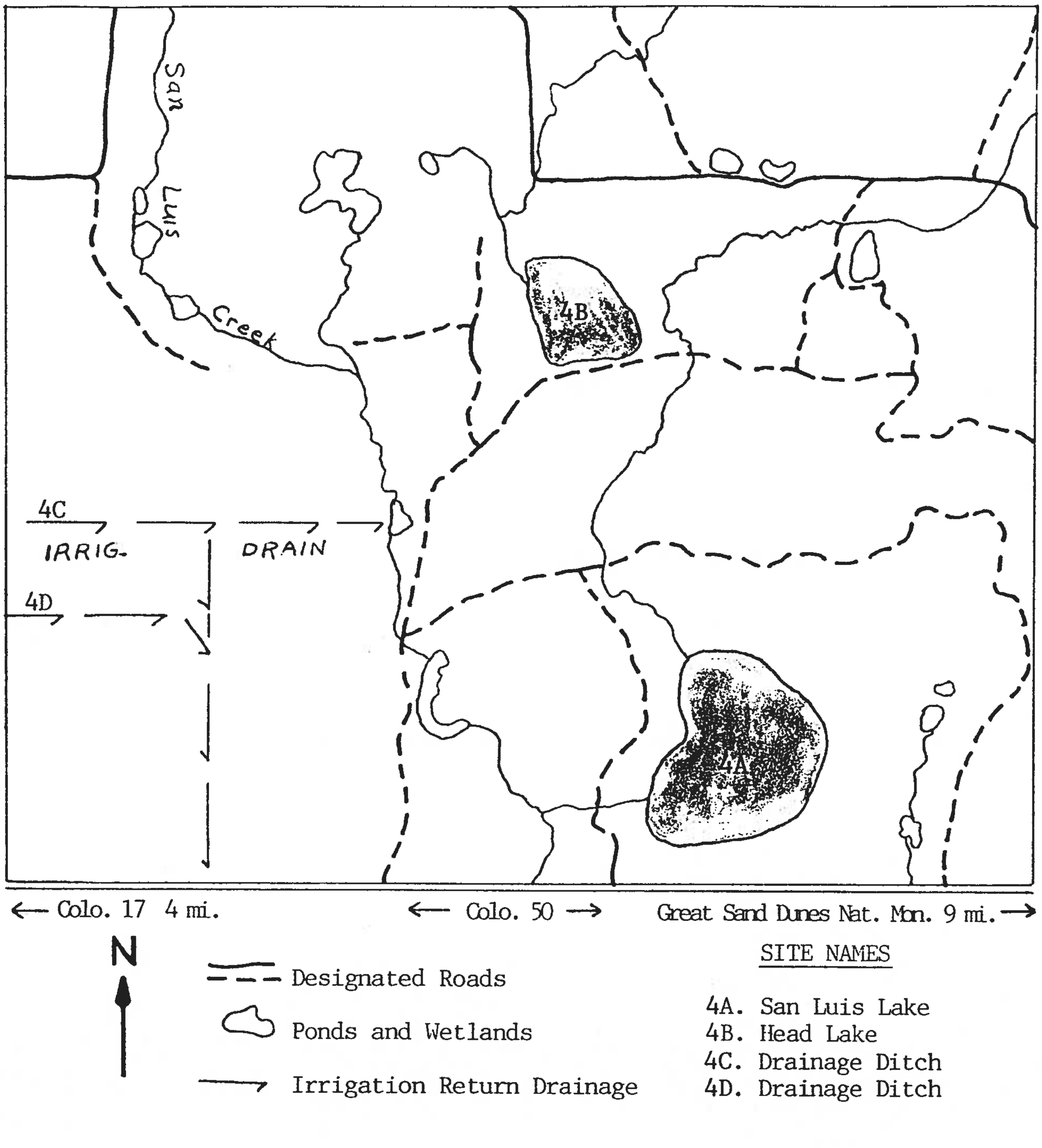

Figure 4. San Luis Lakes State Wildlife Area.

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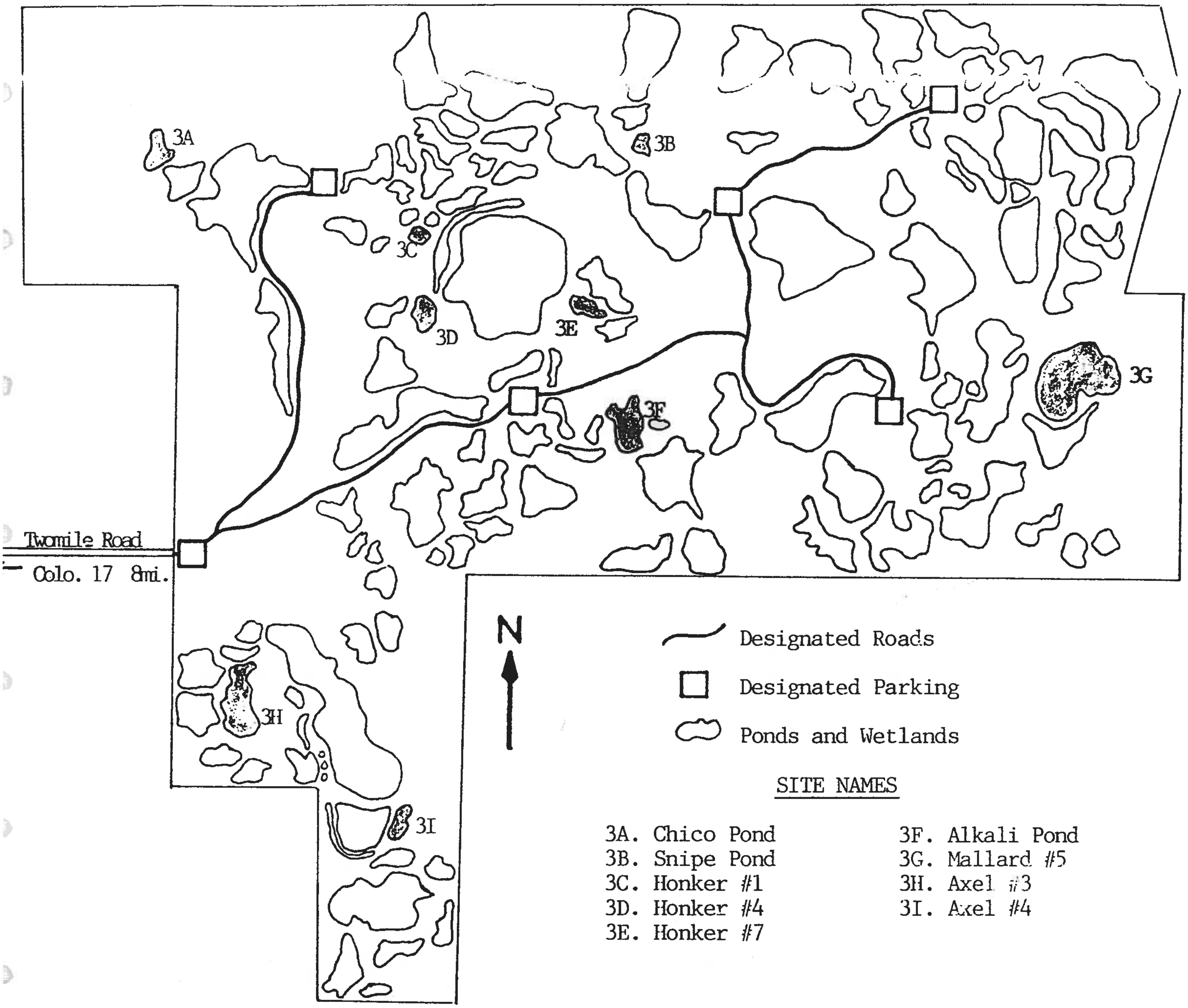

Figure 5. Blanca Wildlife Habitat Area (Dry Lakes). Bureau of Land Management. Many lakes are often dry or have fluctuating water levels.

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The first sampling effort was conducted during June and July, 1987. Biota samples were collected from reservoirs and other areas of high bird use in the closed basin. These samples included sediment, zooplankton, aquatic plants, aquatic invertebrates, fish, and birds collected at lakes and ponds within the resource areas Russel Lakes, San Luis Lakes, and Dry Lakes (Figures 3-5).

The second sampling effort, completed in October, 1987, focused on rivers and tributary streams in and around the San Luis Valley. Most of these are located in the Rio Grande Basin west of the valley and are tributaries to the Rio Grande River, although a few are drainages to the Closed Basin. Many of the drainages sampled had both upstream and downstream collection sites. Sample types collected included water, sediment, aquatic plants, aquatic invertebrates, and fish.

The third sample group was to be collected from the Alamosa/Monte Vista refuge complex and should have been similar in composition to the first two sample groups. As stated previously, this sampling effort was not completed. However, several other groups of samples from the valley were collected for contaminant analyses under this study. In 1988, waterfowl and other migratory birds were collected from the Monte Vista refuge by personnel from the Division, the Colorado CO-OP Unit, and the Service. In 1988-89 fish were collected at San Luis Lake by the Colorado Division of Wildlife for the U. S. Bureau of Reclamation and submitted for analysis by Service personnel. In October 1989, fish fillet samples were collected from the Rio Grande River and analyzed for mercury and selenium. These samples were collected and submitted for analyses by Service personnel for the U. S. Bureau of Reclamation.

Methods

Biological samples were collected using standard equipment and techniques. Birds were shot using steel shot (in most cases), trapped, or found dead. Bird livers were removed using stainless-steel dissecting equipment and placed in chemically cleaned jars, weighed, and frozen. Fish were collected using electroshocking equipment and seine or gill nets. Fish were rinsed, weighed, measured, and immediately frozen on dry ice until they could be stored in a freezer. Whole body and fillet samples were composited by species into groups of three or more fish, when possible. Stream invertebrates were collected with a kick screen, and lake invertebrates were collected with a sweep net. Vascular plants and algae were collected by hand picking. These samples were also placed in chemically cleaned jars, weighed, and frozen. Unfiltered water samples were placed in plastic bottles and frozen. Acidity and alkalinity of water was measured using a standard Ph meter.

Because of the many sample groups collected over a relatively long period of time, samples were analyzed at a variety of laboratories. All samples collected in 1986-87 and the Rio Grande River fish

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fillet samples collected in 1989 were analyzed for inorganic trace elements at Environmental Trace Substances Research Center in Columbia, Missouri. Fish samples collected from San Luis Lake in 1988-89 were analyzed at Colorado State University. Bird samples collected from Monte Vista refuge in 1988 were analyzed at Hazelton Laboratories in Madison, Wisconsin. All organochlorine analyses were done at Mississippi State Chemical Laboratory. Samples were analyzed for either the inorganic trace elements or organochlorine pesticides listed in Table 1. Trace elements were analyzed by either inductively coupled argon-plasma or atomic-absorption spectrometry after acid digestion. Arsenic and selenium were analyzed by hydride-generation atomic absorption, and mercury was analyzed using flameless cold-vapor atomic absorption. Samples analyzed for organic pesticide residues underwent solvent extraction followed by electron-capture gas chromatography.

Concentrations of inorganic trace elements in biological samples are extremely variable and interpreting the data is often difficult and complex. One of the most common methods of interpreting contaminant data is by comparison with data collected from other field studies or laboratory studies which identify common background levels in the environment or concentrations that have been shown to be harmful to biological organisms. A frequently used literature source is the National Contaminant Biomonitoring Program (NCBP) of the U.S. Fish and Wildlife Service. Lowe et al. (1985) report the 85th percentile concentrations for arsenic, cadmium, copper, lead, mercury, selenium, and zinc in whole fish samples collected during 1980-81 at specific locations throughout the United States. The 85th percentile has been established by the NCBP as an arbitrary concentration for distinguishing fish samples containing elevated concentrations of trace elements. It has no meaning with respect to either potential hazards to fishery resources or regulatory statutes. The 85th percentile concentrations in Lowe et al. (1985) are reported as wet weight (fresh weight) concentrations. For comparison purposes, trace element concentrations in the fish samples (reported as dry weight concentrations by the laboratories) were often converted to wet weight concentrations.

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Table 1. Samples were analyzed for either the inorganic trace elements or the organochlorine pesticides listed below.

	Inorganic Trace Elements	
Aluminum	Copper	Nickel
Arsenic	Iron	Selenium
Barium	Lead	Silver
Beryllium	Magnesium	Strontium
Boron	Manganese	Thallium
Cadmium	Mercury	Vanadium
Chromium	Molybdenum	Zinc
	Organochlorine Pesticides	
HCB	r-Chlordane	o,p'-DDD
-BHC	t-Nonachlor	Endrin
r-BHC	Toxaphene	cis-Nonachlor
-BHC	PCB's (total)	o,p'-DDT
-BHC	o,p'-DDE	p,p'-DDD
Oxychlordane	-Chlordane	p,p'-DDT
Hept. Epox.	p,p'-DDE	Mirex
	Dieldrin	

Results and Discussion

Analytical results are listed in tables 4-20 located in the Data Tables section at the end of this report. Tables 4-17 present the results of inorganic analyses, and Tables 18-20 present the results of organic analyses. Inorganic trace elements are expressed as dry weight concentrations in the tables and organochlorine pesticides are expressed as wet weight concentrations. To compare the inorganic data with other toxicological data, the concentrations must sometimes be expressed in terms of wet weight. This can be obtained by multiplying the dry weight concentration by the factor (1 - % moisture).

In the biological samples, levels of barium, beryllium, boron, chromium, iron, magnesium, manganese, molybdenum, nickel, silver, strontium, thallium, and vanadium were generally present at concentrations that would not adversely affect wildlife or humans. Many of those trace elements had concentrations that were less than analytical detection limits. Concentrations of aluminum, arsenic, cadmium, copper, lead, mercury, selenium, and zinc were detected in a variety of matrices from many different areas. Based on comparisons with a variety of literature sources, concentrations of those elements were determined to be elevated in particular matrices from specific locations, rather than widespread.

Aluminum

Aluminum concentrations appeared to be elevated in a variety of matrices, however, background information regarding the toxicity of aluminum to aquatic flora and fauna is extremely limited. Most of the literature available pertains to the toxicity of dissolved aluminum to fish and how it is affected by pH and hardness (Kane and Rabeni, 1987; Baker and Schofield, 1982; Hunn et al., 1987). Brumbaugh and Kane (1985) analyzed organs and whole bodies of smallmouth bass and found that aluminum concentrations in whole fish samples are extremely variable and biased, due to the inclusion of gastrointestinal tract contents. Thus, the aluminum concentrations in the whole-body fish samples collected for this study are difficult to interpret. This may also present a confounding factor when interpreting aluminum levels in whole birds or aquatic invertebrates. For example, the coot whole-body samples (Table 4) contained much higher concentrations of aluminum than the coot liver samples (Table 5).

Aluminum concentrations in water samples were elevated and extremely variable, ranging from <0.03 to 21.4 mg/l (Table 17). Kane and Rabeni (1987) found that acute bioassays conducted at a pH of 5.1 and aluminum concentrations >0.18 mg/l resulted in total mortality of smallmouth bass larvae. Everhart and Freeman (1973) observed acute mortality in rainbow trout fingerlings during exposure to aluminum concentrations of 5.2 mg/l at a pH of 8.0. In general, aluminum toxicity to fish increases as pH decreases (Kane and Rabeni, 1987; Everhart and Freeman, 1973). The water sample that contained the highest aluminum concentration (21.4 mg/l) also had a pH of <4 and was collected from lower Wightman Fork (site 20). The second highest aluminum concentration in a water sample was 8.27 mg/l and was measured in a sample from Bitter Creek (site 21), which also had a pH of <4. The combination of extremely high aluminum concentrations and low pH values could explain the absence of any living organisms at sites 20 and 21.

Aluminum concentrations in sediment samples appeared to be extremely high, however, no background information concerning toxicity of aluminum in aquatic sediments was available.

Arsenic

The toxicity of arsenic to aquatic organisms is well documented. Acute exposure has been shown to result in reduced growth or increased mortality in aquatic organisms (Oladimeji, 1984). In spite of this, there is no evidence for extreme bioaccumulation in aquatic flora and fauna (Moore and Ramamoorthy, 1984).

Mean arsenic concentrations in bird livers (Table 2) are not greater than normal background concentrations (average of 0.3 ug/g fresh weight or about 1.0 ug/g dry weight) found in the livers of seven species of shorebirds wintering in the Corpus Christie, Texas

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area (White et al., 1980). The highest mean arsenic concentration in a bird tissue sample from the San Luis Valley was found in juvenile American coot livers collected during the summer months from Monte Vista National Wildlife Refuge (Table 2). The highest mean arsenic liver concentration among American coots was found in samples from Monte Vista NWR (Table 3). In general, wintering birds had much lower arsenic liver concentrations.

Only two whole fish samples (Table 10) had arsenic levels which exceeded the NCBP's 85th percentile concentration of 0.22 ug/g wet weight (Lowe et al., 1985). These were both fathead minnow samples collected from lower La Jara Creek and La Garita Creek (site numbers 27 and 17, respectively). These arsenic concentrations are considerably less than levels in fish taken from arsenic polluted waters (Sorensen et al., 1985) and within the range of normal background concentrations (Moore and Ramamoorthy, 1984; Jenkins, 1980). Foley et al. (1978) concluded that there are differences between fish species in the rates of uptake and elimination of arsenic.

One aquatic plant sample from Willow Creek (site 9) had an elevated arsenic concentration of 100 ug/g dry weight (Table 14). This concentration is substantially higher than the range of normal arsenic background concentrations in plants from unpolluted water (Moore and Ramamoorthy, 1984; Jenkins, 1980). All other aquatic plant and invertebrate samples were well within normal concentrations.

The average arsenic concentration for 108 sediment samples collected at 9 areas in the western United States was 7.8 ug/g dry weight with a range of 2.4 - 31.0 ug/g (Severson et al., 1987). Most of the sediment samples collected in and around the San Luis Valley had concentrations less than 7.8 ug/g arsenic and only two samples contained more than 31.0 ug/g (Table 16). The sediment sample with the highest arsenic concentration was also collected from Willow Creek (site 9) and contained 130 ug/g arsenic, dry weight. This concentration is greater than background concentrations in sediment samples from uncontaminated lakes (Moore and Ramamoorthy, 1984) and Lake Michigan (NAS, 1977). The arsenic concentration in sediment from lower Wightman Fork (site 20) was 39.0 ug/g dry weight which also exceeds background levels. Only one water sample, also from site 20, contained a relatively high arsenic concentration of 14 ug/l (Table 17) which falls into the range of arsenic concentrations in water samples taken from industrial and agricultural areas (Moore and Ramamoorthy, 1984).

Table 2. Statistical summary of selected inorganic trace element concentrations (ug/g dry weight in bird lier samples. Geometric means are given for the number of samples listed (each sample consists of an individual bird liver) and the range of concentrations are shown in parentheses. [<, less than analytical detection limits]

Variable	SAMPLE GROUP Juvenile mallard	Juvenile mallard	Adult mallard	Juvenile Coot
Number of Samples	8	17	11	13
Collection Period	summers 1987-88	winter 1988	winter 1988	summer 1987-88
Percent Moisture	74.2 (70.1-77.4)	72.8 (71.0-75.1)	72.2 (70.2-75.0)	74.6 (71.4-79.9)
Arsenic	0.28 (<0.20-0.64)	0.13 (0.05-1.17)	0.10 (0.06-0.24)	0.49 (<0.20-2.17)
Copper	32.7 (<11.1-143.0)	84.4 (14.0-267.0)	100.5 (943.3-347.0)	32.3 (<9.1-179.0)
Mercury	0.27 (0.05-0.91)	0.12 (<0.09-0.26)	0.15 (<0.08-0.48)	0.25 (0.08-0.70)
Selenium	6.4 (1.6-13.6)	1.6 (0.71-3.4)	1.7 (0.69-2.5)	2.5 (1.4-6.3)

Variable	SAMPLE GROUP Adult coot	Great Blue Heron	Great horned Owl	Marsh hawk
Number of Samples	14	5	3	3
Collect. Period	summer 1987	winter 1988	winter 1988	winter 1988
Percent Moisture	72.3 (65.7-78.8)	77.9 (73.7-80.2)	74.7 (70.7-77.8)	72.2 (70.8-74.8)
Arsenic	0.30 (<0.20-0.07)	0.07 (<0.019-0.12)	0.06 (<0.021-0.08)	0.05 (0.02-0.075)
Copper	42.3 (13.4-158.0)	134.6 (69.9-335.0)	25.5 (11.3-38.3)	25.3 (13.9-50.1)
Mercury	1.00 (0.08-4.30)	54.20 (12.50-207.0)	2.57 (1.66-5.00)	6.34 (4.01-8.32)
Selenium	3.6 (1.5-11.0)	30.0 (13.6-81.0)	5.1 (3.6-9.2)	6.5 (4.8-8.6)

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Cadmium

Cadmium concentrations in American coot livers and whole-body American coots (Tables 4-5) did not appear to be elevated. All other bird liver samples, and several of the coot liver samples, contained cadmium concentrations which were less than analytical detection limits. The cadmium concentrations measured in American coot livers were less than cadmium levels in the livers of adult mallards fed 2 ug/g cadmium for 90 days (White and Finley, 1978). No adverse affects were observed in that study.

Only one whole-body fish sample (Table 10) collected at Wason Ranch (Rio Grande River - site 10) contained a cadmium concentration greater than the NCBP 85th percentile. This composite sample consisted of five brown trout and contained 0.6 ug/g wet weight (2.3 ug/g dry weight) of cadmium, compared to the 85th percentile concentration of 0.06 ug/g wet weight (Lowe et al., 1985). This concentration is similar to mean cadmium concentrations in several species of fish from an industrially contaminated lake (Murphy et al., 1978).

Cadmium concentrations in aquatic plants (Table 14) were highest in the samples collected at Willow Creek (site 9) and Kerber #3 (site 15); these samples contained 59.9 and 40.6 ug/g dry weight, respectively and appear to be slightly elevated when compared to cadmium concentrations in aquatic plants collected from a variety of polluted areas (Moore and Ramamoorthy, 1984).

Cadmium concentrations in 2 of the 7 aquatic invertebrate samples collected (Table 13) were similar to concentrations in invertebrates from an industrial-zone stream (Anderson, 1977). Those two samples contained 6.2 and 5.6 ug/g dry weight of cadmium and were collected from Wason Ranch (Rio Grande River - site 10) and Bellows Creek (site 11), respectively.

Cadmium concentrations in sediment samples (Table 16) do not appear to be elevated when compared to background concentrations listed in Moore and Ramamoorthy (1984). However, cadmium concentrations in two water samples taken from Kerber #2 (Kerber Creek - site 14) and lower Wightman Fork (site 20), are considerably elevated (Table 17). These samples contained 24 and 18 ug/l, respectively and are greater than cadmium concentrations in the waters of Palestine Lake, Indiana, which receives waste discharge from a nearby electroplating plant (Murphy et al., 1978). In addition, Eisler (1985) states that freshwater cadmium concentrations in excess of 3.0 ug/l may be potentially hazardous to aquatic biota. All other water samples contained < 3.0 ug/l cadmium (Table 17). However, water samples were not taken from Willow Creek (site 9) or Wason Ranch (site 10), where a high influx of metals appears to be occurring.

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Table 3. Concentrations of selected inorganic trace elements in the livers of adult and juvenile American coots. Samples were collected at four locations in the San Luis Valley during the summer months, 1987-88. [concentrations in ug/g dry weight; <, less than analytical detection limits]

	Russell Lakes	San Luis Lakes	Blanca Ponds	Monte Vista NWR
No. of Samples	9	5	7	6
Arsenic	0.3 (<0.2-0.7)	<0.2 (<0.2-<0.3)	0.4 (<0.2-0.7)	1.9 (0.25-2.17)
Copper	26.3 (13.4-40.0)	47.4 (38.5-54.4)	43.8 (13.4-158.0)	15.4 (<9.09-50.6)
Mercury	0.17 (0.08-0.65)	1.7 (0.75-4.30)	1.1 (0.24-3.60)	0.199 (0.102-0.333)
Selenium	3.8 (1.5-11.0)	3.7 (3.0-4.2)	2.1 (1.4-3.9)	2.0 (1.7-6.3)

Copper

Concentrations of copper in bird liver samples appeared to be high and were quite variable (Tables 5-9). The highest copper concentration in a bird sample was found in the liver of an adult mallard found dead on Monte Vista NWR during winter, 1988. This sample contained 347 ug/g copper (dry weight) which is greater than copper concentrations in the livers of 10 juvenile canada geese that died of acute copper toxicosis (Henderson et al., 1975). The livers of those geese contained 56 - 97 ug/g copper, fresh weight (approximately 186 - 323 ug/g dry weight). Of all the waterfowl collected in the valley, adult mallards collected during winter, 1988, had the highest mean copper concentrations in their livers (Table 2) and were exceeded only by great blue herons. Mean copper concentrations in American coot livers were notably higher at San Luis Lakes (site 4) and Russel Lakes (site 5) than at other areas where coots were collected (see Table 3). Mean copper concentrations in bird liver samples (Table 2) are within the range of concentrations measured in the livers of domestic ducks fed 5.7, 12.5, and 27 ug/g copper for 15 weeks (Beck, 1961). None of the birds in that study suffered any visible effects, even though the mean liver copper concentration was 192.7 ug/g dry weight (Beck, 1961). Based on this background information, it appears that the toxicity of ingested copper to waterfowl is dependent, in part, on the duration and amount of exposure. This would indicate that seemingly high liver concentrations could be tolerated if the exposure is chronic at low dietary levels.

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Copper was detected in all of the 40 whole-body fish samples collected (Table 10). Twenty-six of these samples had concentrations which exceeded the 1980-81 NCBP 85th percentile of 0.9 ug/g wet weight, or about 3.6 ug/g dry weight (Lowe et al., 1985). The highest copper concentration measured in a whole fish sample (15 ug/g dry weight) was found in both a rainbow trout sample from Chico Pond (Site 3 - Dry Lakes) and also in a brown trout sample from Wason Ranch (Site 10 - Rio Grande River). All whole-body fish samples had copper concentrations which were considerably less than concentrations in the livers of brown bullheads that died from acute and chronic exposure to copper (Brungs et al., 1973). Most of the fish samples collected in the valley had copper concentrations which were also less than copper concentrations in whole rainbow trout exposed to 30 ug/l of waterborne copper for 7, 14, and 21 days (Dixon and Sprague, 1981).

Moore and Ramamoorthy (1984) state that aquatic invertebrates inhabiting polluted freshwater normally have copper concentrations of 5 - 200 ug/g dry weight while attached aquatic plant species found in polluted waters generally contain residues of 10 - 100 ug/g dry weight. All 7 aquatic invertebrate samples contained copper concentrations of at least 15 ug/g (Table 13). Thirteen of 28 aquatic plant samples had copper concentrations greater than 10 ug/g and three of these were extremely elevated (Table 14). Aquatic plants collected at Willow Creek (site 9), Kerber Creek #3 (site 15), and the lower Alamosa River (site 23) had copper concentrations of 176, 696, and 5570 ug/g dry weight, respectively (Table 14).

Sediments from unpolluted freshwaters generally contained copper concentrations less than 20 ug/g dry weight (Moore and Ramamoorthy, 1984). Copper concentrations in most of the 35 sediment samples were less than this level (Table 16), however, one sediment sample from Kerber Creek #2 (site 14) contained 1250 ug/g copper. This concentration is considered elevated and is consistent with elevated copper levels in sediments associated with the discharge of mine wastes (Moore and Ramamoorthy, 1984). Other sediment samples from Willow Creek, Kerber Creek #3, lower Wightman Fork, and the lower Alamosa River (sites 9, 15, 20, and 23, respectively) had copper concentrations that were somewhat elevated and ranged from 119 to 391 ug/g dry weight (Table 16). It should be noted that these concentrations are consistent with copper concentrations measured in aquatic plant samples from the same sampling sites. In addition, they exceed all of the copper concentrations found in 108 sediment samples collected at 9 areas in the western United States (Severson et al., 1987).

Normal copper concentrations in uncontaminated freshwaters average 0.5 - 2.0 ug/l (Moore and Ramamoorthy, 1984). Only 1 of 8 water samples collected had a copper concentration that fell within this range. The rest of the concentrations are slightly higher (Table 17) and the samples from Kerber Creek #2 (site 14) and lower

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Wightman Fork (site 20) had copper concentrations of 464 and 4940 ug/l, respectively. These concentrations may explain the absence of any aquatic life at those two areas, since a waterborne copper concentration of only 206 ug/l caused acute toxicosis to brown bullheads (Brungs, et al., 1973).

Lead

Lead concentrations in American coot livers (Table 5) were not at elevated levels, except for one adult American coot which had a liver concentration of 22.0 ug/g dry weight. However, this bird may have been collected using lead shot. A small percentage of birds were collected with lead shot during the summer of 1987 due to the unavailability of steel shot in the area. Excluding American coots, all other bird samples had lead concentrations below analytical detection limits.

Only two fish samples had detectable levels of lead (Table 10), both of which exceeded the NCBP 85th percentile concentration of 0.25 ug/g wet weight (Lowe et al., 1985). These samples were a brown trout composite sample (5 fish) from Wason Ranch (Rio Grande River - site 10) and a fathead minnow composite sample (11 fish) from La Garita Creek (site 17). Each contained 2.6 and 2.8 ug/g wet weight, respectively. These concentrations are greater than nationwide mean concentrations for whole fish from 1971 to 1981 (Walsh et al., 1977; May and McKinney, 1981; Lowe et al., 1985) and greatly exceed the recommended guideline concentration for human consumption of 0.3 ug/g fresh weight (World Health Organization, 1972). In addition, these concentrations are greater than any of the concentrations measured in the edible portions of fish collected from the Big River in southeastern Missouri, which has been contaminated by lead mining activities (Czarnezki, 1985). It should be noted that the brown trout sample containing 2.6 ug/g lead consisted of 5 whole fish and that lead concentrations in the edible tissues may be somewhat lower. It should also be noted that many of the analytical detection limits determined for lead in these fish samples are higher than the NCBP 85th percentile. This is due to the use of the inductively coupled argon-plasma (ICP) method for determining lead content, rather than the atomic absorption (AA) method (which provides a lower detection limit).

The highest lead concentration measured in an aquatic plant sample (Table 14) was found in a sample collected from Willow Creek (site 9). This sample contained 3050 ug/g dry weight, which is similar to the mean concentration of 3500 ug/g measured in pondweed samples collected from a site 1.6 km downstream of a Missouri lead mine tailings pond (Jenkins, 1980). The next largest lead concentration in an aquatic plant sample was 300 ug/g dry weight and came from the Kerber Creek drainage (Kerber #3 - site 15).

The highest lead concentration found in an aquatic invertebrate sample was 67 ug/g dry weight and was measured in a sample

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collected from Wason Ranch (Rio Grande R. - site 10). This concentration is larger than mean concentrations of lead measured in crayfish exposed directly to lead-treated soil (containing 1000 ug/g dry weight of lead) for 50 days (Knowlton et al., 1983).

The highest lead concentration measured in a sediment sample, also collected at site 9, was 2950 ug/g dry weight (Table 16). This concentration is greater than the range of concentrations reported by Schmitt and Finger (1982) for sediments collected from the Big River in southeastern Missouri, an area of known contamination from lead mines. The next two highest lead concentrations in sediment samples were 300 and 250 ug/g dry weight and were collected from sites 10 and 14, respectively. Lead concentrations in 108 sediment samples from 9 areas in the western United States averaged 20 ug/g dry weight, with a range of 9-52 ug/g (Severson et al., 1987).

All but one water sample contained lead concentrations less than analytical detection limits (Table 17). However, the analytical detection limits (determined by the type of analysis) for lead concentrations in these water samples was 40 ug/l, which greatly exceeds current recommendations for the protection of aquatic life of 1.3 - 7.7 ug/l (EPA, 1985). The one water sample with a detectable concentration of lead contained 60 ug/l and came from lower Wightman Fork (site 20).

Mercury

Since mercury has no known normal metabolic function, its presence in the cells of living organisms represents contamination from natural and anthropogenic sources and should be considered undesirable and potentially hazardous (NAS, 1978). Biota samples containing greater than 1.0 ug/g fresh weight of methylmercury (the most common form of mercury in biological samples) are considered elevated and are usually associated with human impacts (Eisler, 1987). However, some groups of organisms with consistently elevated mercury residues may have acquired these concentrations through natural processes (Eisler, 1987). It is generally accepted that residues of methylmercury in biological samples are bioconcentrated and biomagnified throughout the upper trophic positions in the food chain (Eisler, 1987).

Mercury concentrations in the tissues of birds are usually highest in predatory species including scavengers and fish eaters (Fimreite, 1974; Braune, 1987) and are significantly affected by food preference and availability, and by migratory patterns (NAS, 1978; Delbeke et al., 1984). The highest mercury concentrations in any bird samples collected in the San Luis Valley were detected in the livers of great blue herons found dead on Monte Vista NWR during winter, 1988 (Table 6). These samples contained an average mercury concentration of 19.6 ug/g wet weight (81.7 ug/g dry weight) which is slightly less than concentrations in the livers of six adult great blue herons collected from a mercury contaminated

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freshwater system in northwestern Ontario (average of 40.3 ug/g wet weight or about 134 ug/g dry weight; Fimreite, 1974). Dustman et al. (1970) reports even higher mercury concentrations averaging approximately 98.0 ug/g wet weight (about 320 ug/g dry weight) in the livers of great blue herons collected at Lake St. Clair, also in Ontario. Great blue heron livers from New Brunswick, Lake Erie, and Wisconsin all had comparatively lower mercury concentrations of 0.2 - 4.5 ug/g wet weight or about 0.67 - 15.0 ug/g dry weight (Jenkins, 1980).

Lethality as a direct result of mercury toxicity has been documented in other bird species whose livers contained mercury concentrations similar to the most contaminated great blue heron livers from Monte Vista NWR. For example, Keoman et al. (1971) reported mean liver concentrations of 83 ug/g wet weight (about 277 ug/g dry weight) in kestrels that died of eating mice containing an average of 13.3 ug/g mercury (fresh weight). Several species of passerines that died of mercury toxicity contained mean liver concentrations of 54.5 - 126.5 ug/g wet weight or approximately 182 - 422 ug/g dry weight (Finley et al., 1979). That study concluded that concentrations of mercury in excess of 20 ug/g wet weight in soft tissues should be considered extremely hazardous to the health of the bird. Fimreite and Karstad (1971) reported visible effects of mercury poisoning in red-tailed hawks with liver concentrations of 20 ug/g wet weight and greater. Two of the great blue herons collected at Monte Vista National Wildlife Refuge had liver concentrations of approximately 32 and 62 ug/g wet weight (106 and 207 ug/g dry weight).

Mercury concentrations in the livers of one of three great horned owls and three of three marsh hawks (also found dead at Monte Vista National Wildlife Refuge during winter, 1988) were greater than 4.0 ug/g dry weight, which is approximately equal to 1.0 ug/g wet weight (Table 6). These concentrations are elevated, however, they probably represent normal background concentrations for predatory bird species.

The highest mercury concentrations found in any of the waterfowl liver samples were 3.6 and 4.3 ug/g dry weight, which, when converted to fresh weight concentrations, are slightly greater than 1.0 ug/g. These two samples are from adult American coots collected during summer, 1987 (Table 5) from San Luis Lakes (site 4) and Russel Lakes (site 5 - see Table 3). All other waterfowl livers contained mean mercury concentrations (Table 2) ranging from less than detection limits to 1.8 ug/g dry weight). These concentrations are lower than concentrations found in livers of waterfowl collected from areas with potential or existing mercury contamination (Vermeer and Armstrong, 1972; Krapu at. al., 1973; Lindsay and Dimmick, 1983).

Four of the 40 whole-body fish samples collected in and around the San Luis Valley contained mercury concentrations (Table 10) which

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were greater than the NCBP 85th percentile of 0.18 ug/g wet weight (approximately 0.7 ug/g dry weight; Lowe et al., 1985). Of these four, the highest mercury concentration detected was 2.0 ug/g dry weight (0.52 ug/g wet weight) found in a brown trout composite sample consisting of two fish collected from Saguache Creek (site 16).

Eleven of the 18 muscle tissue (fillet) samples of fish collected from the Rio Grande River (Table 11) also contained mercury concentrations which exceeded the NCBP 85th percentile. The two fillet samples with the most extensive mercury contamination contained 2.3 and 2.1 ug/g dry weight (0.38 and 0.45 ug/g wet weight, respectively). Those fillet samples were taken from three Rio Grande Suckers (2.3 ug/g) and three Northern Pike (2.1 ug/g) collected at sites 29 and 2B, respectively. Mercury concentrations in tissue samples (muscle, liver, and kidney) of rainbow trout collected from San Luis Lake (Table 12) did not exceed the NCBP 85th percentile. Residues of mercury in all fish samples collected from the valley fall within the range of concentrations in whole fish collected nationwide during 1969-72 and 1976-81 (Henderson and Shanks, 1973; Lowe et al., 1985) and are similar to the mean concentrations for those studies.

None of the fish samples collected from the valley had a mercury concentration greater than the U.S. Food and Drug Administration's (FDA) "action level" of 1.0 ug/g wet weight. This guideline was determined by the FDA as the maximum allowable mercury concentration in fish and seafood to be used for human consumption (U.S. Food and Drug Administration, 1978). Other sources of literature (Wallace et al., 1971; Phillips et al., 1980; Cox et al., 1979) cite earlier FDA guidelines for mercury concentrations in fish and shellfish prepared for human consumption of <= 0.5 ug/g (fresh weight) as a safe level. Humans worldwide should not consume seafood containing greater than 0.4 - 1.0 ug/g mercury and not more than 0.5 ug/g in the United States (NAS, 1978). Pregnant women should not consume fish or seafood containing more than 0.25 ug/g wet weight (Khera, 1979). Based on these criteria, mercury concentrations in fish from the valley generally do not exceed guidelines for human consumption, except for pregnant women.

Mercury concentrations in aquatic invertebrate samples from tributary streams in the valley (Table 13) contain less mercury than aquatic invertebrates found in contaminated areas (Huckabee et al., 1979; Hildebrand et al., 1980) and are at the low end of the range of concentrations for invertebrates found in uncontaminated areas (Huckabee et al., 1979).

Mercury residues in aquatic plant samples (Table 14) are similar in concentration to levels found in vascular aquatic plants from industrial areas (Sarkka et al., 1978; Dietz, 1972). Two aquatic plant samples, collected from upper Wightman Fork (Site 19) and the lower Alamosa River (site 23) contained 0.10 and 0.19 ug/g mercury, dry weight (Table 14). These concentrations, when converted to wet weight, are less than the range of safe mercury levels of 0.05 - <0.1 ug/g fresh weight recommended for the diet of sensitive avian species (Eisler, 1987). Concentrations in pondweed samples from the Alamosa/Monte Vista NWR (sites 1 and 2) approach the upper end of this range.

Concentrations in two of four plankton samples are much greater than mercury levels in plankton samples from a Finland lake in close proximity to pulp and paper mills (Sarkka et al., 1978). These two plankton samples were collected from irrigation return drains (sites 4C and 4D - see figure 4) flowing into San Luis Lake and contained 2.20 and 2.35 ug/g mercury, dry weight (Table 15).

Mercury concentrations in all 35 sediment samples collected in and around the valley (Table 16) were less than the average mercury concentration of 0.6 ug/g dry weight for 108 sediment samples collected at 9 areas in the western United States (Severson et al., 1987). Only four sediment samples had mercury residues greater than the range of mercury concentrations (0.004 - 0.06 ug/g dry weight) for sediment collected in Lake Superior (Damiani and Thomas, 1974). The mercury levels in sediment from Lake Superior represent low concentrations from natural sources (Damiani and Thomas, 1974).

Mercury concentrations in water samples from tributary streams average 0.33 ug/l with a range of 0.3 - 0.4 ug/l. These concentrations are greater than mercury levels in unpolluted lakes and rivers in Canada which average 0.03 ug/l (D'Itri, 1972) and are within the range of concentrations (0.1 - 4.1 ug/l) for water samples taken near gold mining operations in South Dakota (Martin and Hartman, 1984).

Selenium

Selenium concentrations in bird samples appeared to be low for the most part, with a few scattered elevated values. The highest selenium concentrations were found in liver samples from great-blue herons (Table 6). Heinz (pers. comm., 1990) states that avian livers with more than 20 ug/g selenium wet weight (approximately 70 ug/g dry weight) indicates that heavy exposure to selenium may have taken place and should be considered a possible threat to the health of the bird. The average selenium concentration (8.7 ug/g wet weight) for five great-blue heron liver samples (Table 6) did not exceed this guideline, and only one great-blue heron liver had a concentration greater than 20 ug/g wet weight. This liver sample contained 21.3 ug/g wet weight (81 ug/g dry weight) and is from the same bird that had a mercury concentration of 207 ug/g dry weight.

Of all the waterfowl samples from the San Luis Valley, livers from juvenile mallards collected during the summer had the highest mean selenium concentration of 6.4 ug/g dry weight (Table 2). This same

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group of samples also had the highest individual selenium concentration measured in a bird liver sample other than a great-blue heron liver (13.6 ug/g dry weight; Table 2). Adult American coots collected during the summer had a similar range of selenium concentrations in their livers as the juvenile mallards although the mean was lower (Table 2). Among the coot liver samples, higher selenium concentrations were evident at San Luis Lakes (site 4) and Russel Lakes (site 5; see Table 3). Heinz et al. (1987) reports mean selenium concentrations of 2.4 - 5.5 ug/g wet weight (approximately 8.0 -18.0 ug/g dry weight) in the livers of 10 adult mallards (five drakes and five hens) that were fed 25 ug/g selenium as sodium selenite. This diet caused drakes to have significantly higher selenium burdens in their livers than hens; one drake died after 57 days with a liver concentration of 6.1 ug/g wet weight (approximately 20 ug/g dry weight). Embryotoxic effects and reduced duckling survival rates were also observed (Heinz et al. 1987).

Four juvenile mallards collected during summer, 1988, at Monte Vista NWR (Site 1A) had liver concentrations of 2.4 - 3.1 ug/g wet weight (9.0 - 13.6 ug/g dry weight; see Table 7). One adult American coot collected at Russel Lakes (Site 5D) had a liver concentration of 3.2 ug/g wet weight (11.0 ug/g dry weight). These concentrations are within the range of selenium concentrations (2.4 - 9.1 ug/g wet weight or about 8.0 - 30.0 ug/g dry weight) measured in the livers of adult mallards (both sexes) fed 4 and 8 ug/g selenium as selenomethionine (Heinz et al., 1989). This range represents a threshold level at which reduced reproductive abilities were observed (Heinz et al., 1989). However, only the five waterfowl liver samples had selenium concentrations in this range; most of the remaining 64 waterfowl liver samples were well below this threshold level.

Concentrations of selenium in the livers of great-horned owls and marsh hawks were similar to some of the higher selenium concentrations measured in waterfowl livers (Table 6).

Selenium concentrations in fish samples appeared to be low and consistent (Tables 10-12). Concentrations of selenium in 4 of 40 whole body fish samples (Table 10) were greater than the NCBP 85th percentile concentration of 0.71 ug/g wet weight or about 2.8 ug/g dry weight (Lowe et al., 1985). Concentrations in muscle tissue (fillet) samples from fish collected in the Rio Grande River and San Luis Lake (Tables 11-12) were considerably less than the NCBP 85th percentile. Two liver samples and one kidney sample from rainbow trout collected at San Luis Lake contained 12.04, 8.63, and 4.05 ug/g selenium dry weight, respectively. These concentrations are similar to concentrations measured in the livers and kidneys of rainbow trout in a control group that were not exposed to waterborne selenium (Hodson et al., 1980).

Selenium concentrations in aquatic plant, aquatic invertebrate, and

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plankton samples appeared to be low (Tables 13-15). Twenty-three of 28 aquatic plant samples were within the range of mean selenium concentrations found in algae and rooted aquatic plants from an uncontaminated control area (Ohlendorf, 1989). Ohlendorf (1989) also reported mean selenium concentrations for plankton and aquatic insect samples from uncontaminated control areas that were similar to or greater than concentrations measured in all of the plankton and invertebrate samples collected during this study.

Selenium concentrations in sediment and water samples also appeared to be low. Selenium concentrations in sediment samples were considerably less than the average selenium concentration for 108 sediment samples collected at nine areas in the western United States (Severson et al., 1987). Selenium concentrations in water samples ranged from < 0.4 to 1.0 ug/l (Table 17). Shamberger (1981) indicates that selenium concentrations of >2 - 5 ug/l in water are levels of concern for fish and waterfowl.

Zinc

Zinc concentrations in waterfowl livers (Tables 4-9) were similar to concentrations measured in the livers of mallard ducks which were not given any supplemental dietary zinc (Gasaway and Buss, 1972). Those mallards were a control group for a study in which domestic mallards were fed extremely high concentrations of zinc (Gasaway and Buss, 1972). Zinc concentrations in the livers of great-blue herons and marsh hawks (Table 6) were higher than the concentrations in the waterfowl livers.

Six of the 40 whole-body fish samples (Table 10) contained zinc concentrations greater than the NCBP 85th percentile concentration of 40.09 ug/g wet weight (Lowe et al., 1985). Four of these were carp samples which averaged 64 ug/g wet weight. Lowe et al. (1985) have demonstrated that carp may have a tendency to accumulate more zinc than other species. The other two fish samples with zinc concentrations greater than the 85th percentile were a fathead minnow sample (11 fish) from La Garita Creek (site 17) and a brown trout sample (5 fish) from Wason Ranch (Rio Grande River - site 10). These two samples contained zinc concentrations of 220 and 197 ug/g dry weight (approximately 48 and 50 ug/g wet weight) and were similar to mean zinc concentrations in several species of fish (whole body samples) taken from an industrially contaminated lake (Murphy et al. 1978).

The four highest zinc concentrations found in aquatic plant samples (Table 14) occurred in the samples from Willow Creek (site 9), Kerber Creek (Kerber #3 - site 15), the lower Alamosa River (site 23), and Wason Ranch (Rio Grande River - site 10) and ranged from 1060 to 17400 ug/g dry weight. These concentrations are comparable to levels which occurred in various aquatic macrophytes collected from mining areas of eastern and northern Canada (Franzin and

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McFarlane, 1980). No aquatic plants were available at sites upstream of site 15 and site 23 for comparison.

The only aquatic invertebrate sample that had an elevated zinc concentration was collected from site 10 and contained 1070 ug/g dry weight (Table 13). Again, no aquatic invertebrates were available from site 9 or the Kerber Creek and Wightman Fork drainages for comparison.

Four sediment samples collected from sites 9, 10, 14, and 15 (Table 16) had zinc concentrations ranging from 755 to 9690 ug/g dry weight with an average concentration of approximately 4349 ug/g. These concentrations are within the range of concentrations found in the sediments of a freshwater lake that was contaminated by metal mining activities (Maxfield et al., 1974). All other sediment samples had zinc levels within the range of concentrations measured in 108 sediment samples at 9 areas in the western United States, and most are well below the average of that range (Severson et al., 1987).

Two water samples collected from Kerber #2 (Kerber Creek - site 14) and lower Wightman Fork (site 20) contained 7060 and 2390 ug/l, respectively (Table 17). These concentrations are consistent for freshwaters in proximity to metal mining and industrial areas (Moore and Ramamoorthy, 1984).

Organochlorine Pesticides

Trace concentrations of p,p'-DDE, p,p'-DDD, and oxy-chlordane were detected in American coot liver samples (Table 18), however, these concentrations were very low. A few low levels of p,p'-DDE were also detected in aquatic invertebrate, plant, plankton, and sediment samples (Table 20). No polychlorinated biphenyl (PCB) residues were detected in any samples.

Trace concentrations of p,p'-DDE were detected in most of the whole body fish samples analyzed for organochlorines (Table 19). The highest of these concentrations were 1.9, 2.3, 1.2, and 0.53 ug/g wet weight and were measured in a northern pike sample (3 fish), two white sucker samples (4 and 5 fish each), and a carp sample (4 fish), respectively. All of these samples were collected from Bowen Drain (Monte Vista NWR - site 1B). These concentrations are substantially higher than the geometric mean concentration of 0.2 ug/g wet weight for p,p'-DDE in whole fish samples collected during 1980-81 by the National Pesticide Monitoring Program (Schmitt et al., 1985). The maximum p,p'-DDE concentration found in a composite fish sample by the National Pesticide Monitoring Program (NPMP) during 1980-81 was only 2.57 ug/g wet weight. The samples from Bowen Drain (site 1B) had the most extensive organochlorine contamination of all the fish samples collected during this study (Table 19). The northern pike sample and one of the white sucker samples from this area contained concentrations of p,p'-DDD and p,p'-DDT which were greater than the geometric mean concentrations of these compounds (0.07 and 0.05 ug/g, respectively) in fish samples collected by the NPMP (Schmitt et al., 1985). The other white sucker sample from site 1B also had p,p'-DDD a concentration which was greater than the NPMP geometric mean. In addition, one white sucker collected at San Luis Lake (site 4A) contained concentrations of p,p'-DDE and Toxaphene that were greater than the NPMP mean concentrations for those compounds (Schmitt et al., 1985). The toxaphene concentration in that sample was 1.3 ug/g wet weight, which is substantially higher than the geometric mean of 0.27 ug/g (Schmitt et al., 1985).

Conclusions

The combined results of all the sampling efforts reported here for the San Luis Valley have identified two major concerns. One of these is the high concentrations of mercury and selenium found in the livers of great blue herons and high concentrations of copper, mercury, and selenium were also found in waterfowl livers, although these were extremely variable. The second major concern (and possibly the most noteworthy) is the identification of three areas of stream drainage which receive large amounts of mine runoff and appear to contribute high concentrations of metals and other trace elements to the San Luis Valley. Samples collected at stream and river sites which are apparently not impacted by mine drainage have, for the most part, much lower concentrations of trace elements.

The high concentrations of mercury and selenium in the livers of great blue herons propagate questions about the great blue heron population residing in the San Luis Valley. Specific factors that may influence the contamination of great blue herons include their migration patterns, their period of residency in the valley, food habits, and nesting locations. In addition, the high concentrations of selenium in the birds may protect them from the toxic effects of mercury and other heavy metals, but the extent of this is not known (Eisler, 1985). This is a distinct possibility since there appears to be a correlation between mercury and selenium concentrations in each great blue heron liver as well as the great horned owl and marsh hawk livers (Table 6.)

Although it is not known whether the great blue herons found at Monte Vista NWR died of mercury toxicity, the available background information indicates that great blue herons can potentially accumulate large concentrations of mercury without visible adverse effects (Fimreite, 1974; Dustman et al., 1970). Eisler (1987) recommends that the diet of sensitive avian species (e.g. waterfowl) contain less than 0.1 ug/g mercury (fresh weight) to avoid adverse reproductive effects. There were several whole fish samples that had wet weight mercury concentrations above this threshold level. However, birds that consume fish in the San Luis Valley such as great blue herons, mergansers, and eagles are

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probably not considered "sensitive" and possibly have adapted to the high mercury levels typically found in the tissues of these species.

The three areas identified as sources of large amounts of heavy metals occur in geologically separate areas and receive runoff from areas with high mining activity, both past and present. The drainages in question are: 1) the Kerber Creek drainage, located in the extreme northern end of the valley; 2) the Willow Creek drainage, a tributary to the Rio Grande River west of the valley; and 3) the Wightman Fork drainage, a tributary to the Alamosa River also west of the valley.

The metal loading to Kerber Creek appears to be occurring mainly via Rawley Gulch and Copper Gulch, two drainages in areas of high mining activity that were not sampled. However, two areas above (sites 12 and 13) and below (sites 14 and 15) the confluence of these drainages with Kerber Creek were sampled. In addition, Squirrel Creek, also a tributary to Kerber Creek but located upstream of all the sampling sites, probably contributes large quantities of metals to Kerber Creek. Willow Creek and Wightman Fork are located directly in areas of high mining activity and are being directly impacted by mine tailings and runoff.

To illustrate the quantity of metals and other trace elements that these three drainages are contributing to downstream areas, all of the sediment samples collected were placed in one of four groups, based on the location of the sampling site. Geometric means were calculated for concentrations of aluminum, arsenic, cadmium, copper, lead, mercury, selenium, and zinc in the sediment samples of each group. The four groups are: A) Sample sites which appear to be directly impacted by upstream mining activities (sites 9, 10, 14, 15, 20, and 23); B) Sample sites which appear to be either upstream of mining activities or are not directly impacted by mining activities (all other stream or river sites where sediment samples were collected - see Table 16); C) Sample sites at Alamosa/Monte Vista NWR (see Table 16); and D) Sample sites at other lake and pond areas in the San Luis Valley (see Table 16). Figures 6-7 illustrate the differences in geometric mean concentrations for the respective element between each group of sediment samples. Ideally, this comparison should be done for all sample matrices grouped in the same way. However, this was not possible due to inconsistencies in the types of samples collected at each site. Specifically, the most contaminated areas (e.g. the three drainages mentioned previously) were very limited as to the types of samples that could be collected. In some cases, the sample site was so contaminated that there was a complete absence of any aquatic life (sites 14 and 20, for example). Thus, sediment was the only matrix collected at enough sample sites to be compared in this way.

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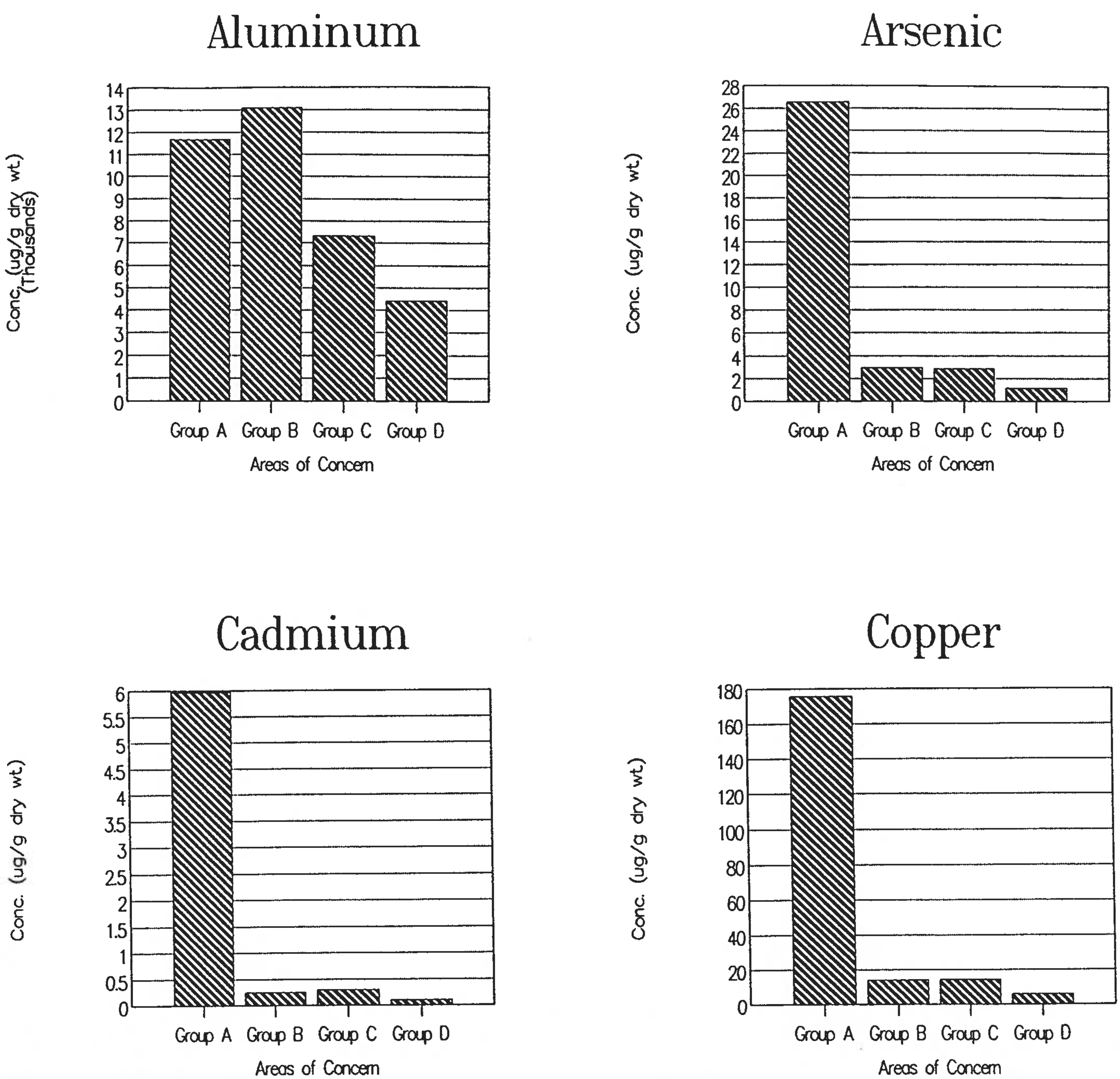
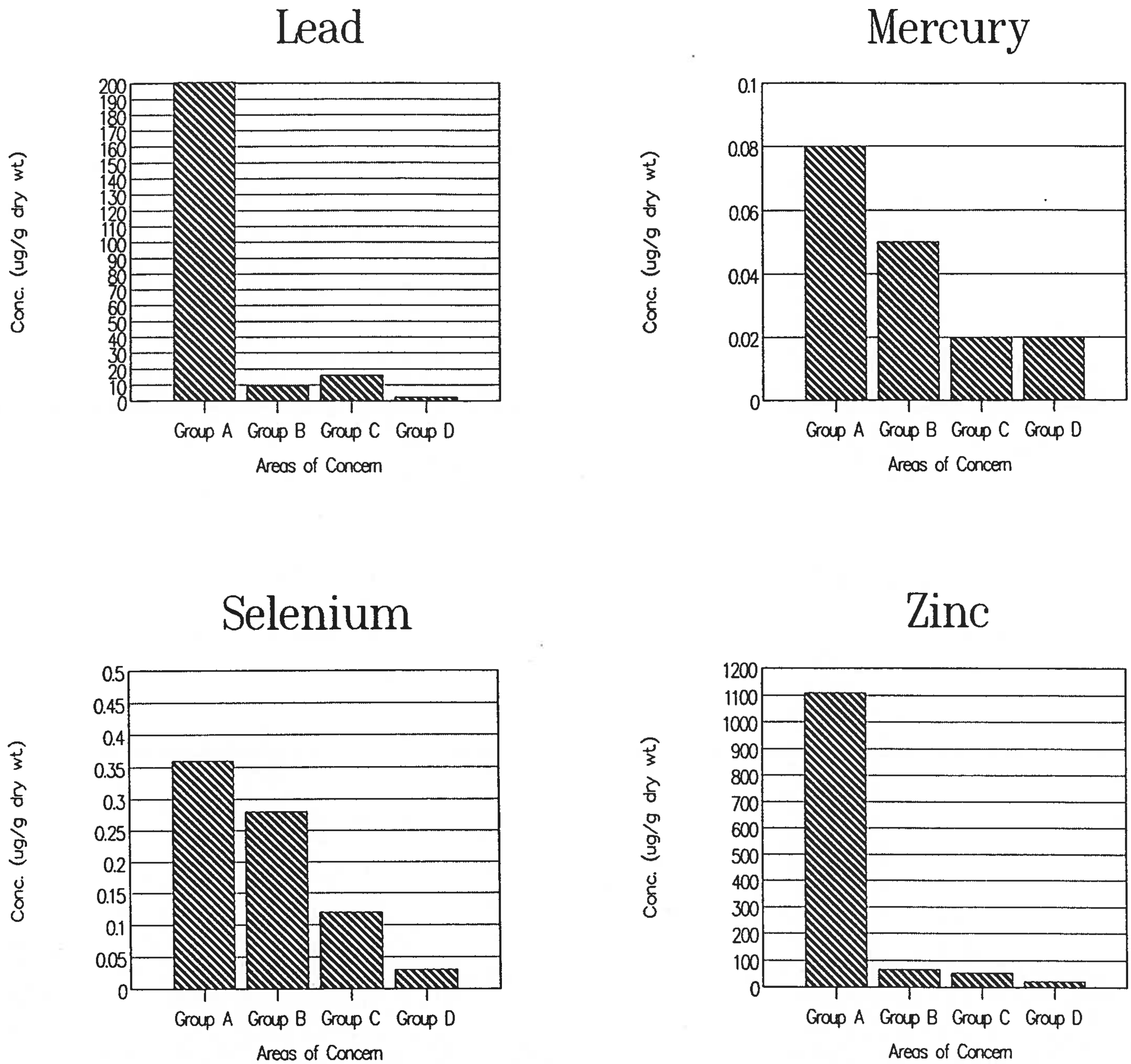


Group A. Streams and rivers recieving direct mine drainage.
Group B. Streams and rivers not recieving direct mine drainage.
Group C. Alamosa/Monte Vista National Wildlife Refuge.
Group D. Other lake, pond, and wetland areas in the valley.

Figure 6. Geometric mean concentrations of aluminum, arsenic, cadmium, and copper in sediments from four different groups of sampling sites.



Group A. Streams and rivers recieving direct mine drainage.
Group B. Streams and rivers not recieving direct mine drainage.
Group C. Alamosa/Monte Vista National Wildlife Refuge.
Group D. Other lake, pond, and wetland areas in the valley.

Figure 7. Geometric mean concentrations of lead, mercury, selenium, and zinc in sediments from four different groups of sampling sites.

These results indicate that potentially, fish and wildlife populations in certain areas of the San Luis Valley could be exposed to harmful concentrations of metals and other trace elements. Most likely, this exposure would occur via bioconcentration through the food chain. Unfortunately, the areas that appeared to have the most extensive contamination of metals and other trace elements also had very few samples collected, simply because of a lack of aquatic organisms. Thus, it was difficult to identify any trends in food chain biomagnification with regard to inorganic contamination.

Recommendations

Future contaminant studies in the San Luis Valley should essentially be scaled-down versions of this study which concentrate on small areas or populations with known or suspected contamination. For example, the stream drainages identified in this report that are being impacted by mining activities should be investigated in greater detail. Another practical study would be to assess the extent of mercury and selenium contamination occurring in the wading and/or fish eating bird populations in the valley (such as great blue herons). For these types of studies, sampling efforts should be concentrated on collecting a variety of sample matrices from specific locations. This would allow the identification of potential food chain bioaccumulation of contaminants between different trophic levels.

DATA TABLES 4-20

Concentrations of inorganic trace elements expressed in terms of dry weight (Tables 4-16). Concentrations of organochlorine pesticides expressed in terms of wet weight (Tables 18-20). Concentrations in water samples expressed in mg/l (Table 17).
[<, less than analytical detection limits]

Table 4. Concentrations of inorganic trace elements in whole body American coot samples collected from Alamosa/Monte Vista NWR (sites 1A and 2A).

Variable	Site Numbers 1A	1A	1A	2A	2A
Date Collected	08/15/86	08/15/86	08/15/86	08/15/86	08/15/86
Age	adult	adult	adult	adult	adult
Percent Moisture	71.5	73.2	73.8	73.8	72.9
Aluminum	288.0	394.0	845.0	233.0	577.0
Arsenic	0.36	0.48	0.43	0.42	0.30
Beryllium	<0.01	<0.01	<0.01	<0.01	<0.01
Cadmium	0.05	0.04	0.12	0.14	0.13
Chromium	0.2	0.8	1.0	8.8	11.0
Copper	6.0	7.1	9.7	27.4	24.1
Iron	1360.0	1590.0	2760.0	870.0	1540.0
Lead	<0.4	<0.4	2.4	0.8	<0.5
Manganese	11.5	14.9	81.0	125.0	33.2
Mercury	0.05	0.09	0.17	0.10	0.21
Nickel	<0.1	<0.1	0.5	4.7	5.0
Selenium	1.0	1.0	1.1	1.3	0.9
Thallium	<0.9	<1.0	<1.0	<0.9	<1.0
Zinc	84.5	69.9	105.0	114.0	121.0

Table 5. Concentrations of inorganic trace elements in the livers of American coots collected in the San Luis Valley during the summer months, 1987-88.

Variable	Site Numbers 1A	1A	1A	1A	1A	1A	3E	3G	5C
Date Collected	7/88	7/88	7/88	7/88	7/88	7/88	07/21/87	06/24/87	07/21/87
Age	juvenile	juvenile	juvenile	juvenile	juvenile	juvenile	juvenile	juvenile	juvenile
Percent Moisture	73.5	76.6	74.7	75.7	72.5	76.6	73.6	75.9	71.4
Aluminum	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	4.0	<3.0	9.9
Arsenic	0.37	1.13	2.02	0.33	2.17	0.25	<0.3	<0.3	<0.3
Barium	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0.2	0.1	0.6
Beryllium	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.1	<0.1	<0.1
Boron	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<2.0	<2.0	<2.0
Cadmium	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.11	0.29	0.06
Chromium	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	<0.9	1.0
Copper	50.6	20.9	11.5	36.6	<9.1	38.9	73.1	179.0	27.7
Iron	1430.0	1990.0	1670.0	1330.0	1590.0	603.0	1570.0	757.0	414.0
Lead	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<0.5	<0.5	<0.5
Magnesium	906.0	855.0	593.0	658.0	582.0	769.0	720.0	869.0	767.0
Manganese	11.7	15.0	8.3	10.3	10.2	14.5	12.0	9.2	11.0
Mercury	0.21	0.33	0.19	0.25	0.10	0.12	0.70	0.49	0.12
Molybdenum	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	2.9	2.5	1.9
Nickel	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	0.4	<0.2	0.6
Selenium	1.9	2.1	6.3	2.9	3.6	1.7	1.4	1.6	2.8
Silver	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<1.0	<1.0	<1.0
Strontium	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	0.63	0.56	0.70
Thallium	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.5	<0.5
Vanadium	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0.10	<0.5	0.10
Zinc	134.0	102.0	78.3	119.0	74.2	137.0	213.0	145.0	163.0

Table 5. (continued)

Variable	5D	5D	5D	5D	3C	3E	3G	3G	3H
	Site Numbers								
Date Collected	07/21/87	07/21/87	07/21/87	07/21/87	07/21/87	07/21/87	06/24/87	06/24/87	07/21/87
Age	juvenile	juvenile	juvenile	juvenile	adult	adult	adult	adult	adult
Percent Moisture	73.5	72.8	72.6	79.9	76.3	72.1	71.8	71.2	71.5
Aluminum	<3.0	<3.0	19.0	<3.0	5.0	16.0	20.0	15.0	9.9
Arsenic	0.3	0.3	<0.2	<0.3	0.3	0.3	<0.2	<0.2	0.5
Barium	0.3	0.3	1.9	0.2	0.2	<0.1	0.9	<0.1	0.2
Beryllium	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Boron	<2.0	<2.0	<2.0	6.4	<2.0	<2.0	<2.0	<2.0	2.0
Cadmium	0.11	0.08	0.09	0.14	2.20	2.70	0.59	5.39	4.17
Chromium	<0.9	<0.9	<0.9	<0.9	0.9	<0.9	<0.9	<0.9	<0.9
Copper	26.7	20.7	39.3	34.3	106.0	37.2	14.9	89.1	158.0
Iron	741.0	922.0	475.0	492.0	4050.0	2250.0	2600.0	2930.0	3730.0
Lead	<0.5	<0.5	<0.5	<0.5	22.0	<0.5	<0.5	<0.5	0.8
Magnesium	584.0	626.0	556.0	730.0	712.0	693.0	793.0	733.0	696.0
Manganese	7.3	7.7	13.0	13.0	8.4	7.6	9.2	11.0	7.0
Mercury	0.08	0.10	0.11	0.65	1.30	0.75	0.24	1.80	3.60
Molybdenum	2.2	2.5	1.9	3.1	13.0	12.0	2.9	5.6	5.3
Nickel	<0.2	<0.2	<0.2	1.7	<0.2	<0.2	<0.2	<0.2	1.2
Selenium	3.5	3.4	1.5	2.7	1.9	2.4	1.5	3.9	3.2
Silver	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Strontium	0.28	0.27	1.70	1.20	0.67	0.20	1.20	0.45	0.69
Thallium	<0.4	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Vanadium	0.10	0.10	0.19	0.06	0.38	1.10	0.60	2.90	0.46
Zinc	102.0	123.0	126.0	166.0	186.0	166.0	118.0	195.0	166.0

Table 5. (continued)

Variable	4A	4A	4A	4A	4B	5C	5C	5D	5D
	Site Numbers								
Date Collected	06/23/87	06/23/87	06/23/87	06/23/87	06/23/87	07/21/87	07/21/87	07/21/87	07/21/87
Age	adult	adult	adult	adult	adult	adult	adult	adult	adult
Percent Moisture	74.7	73.9	70.4	73.7	78.8	69.4	72.4	65.7	70.7
Aluminum	<3.0	3.0	<3.0	5.0	30.0	9.2	6.0	22.0	37.0
Arsenic	<0.3	0.2	0.2	<0.2	0.2	0.5	0.7	0.5	0.4
Barium	0.1	0.1	<0.1	<0.1	0.2	1.6	1.8	1.2	0.5
Beryllium	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1
Boron	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Cadmium	1.60	0.45	1.50	1.00	0.99	0.30	0.99	0.69	1.20
Chromium	<0.9	<0.9	<0.9	<0.9	2.0	1.0	<0.9	<0.9	<0.9
Copper	38.5	50.6	54.4	46.6	48.4	18.2	13.4	40.0	29.8
Iron	3620.0	2360.0	5100.0	1080.0	833.0	2800.0	11200.0	2620.0	3840.0
Lead	<0.5	<0.5	<0.6	<0.5	0.5	<0.5	<0.6	0.8	0.5
Magnesium	529.0	676.0	774.0	787.0	745.0	697.0	763.0	632.0	701.0
Manganese	5.7	9.2	10.0	9.9	10.0	6.2	7.5	10.0	12.0
Mercury	4.30	1.80	1.70	0.75	1.20	0.08	0.16	0.14	0.17
Molybdenum	3.0	4.0	4.7	3.1	3.5	4.0	6.9	3.8	14.0
Nickel	3.2	<0.2	<0.2	<0.2	0.3	<0.2	<0.2	<0.2	<0.2
Selenium	3.0	4.2	3.7	3.9	3.6	4.5	4.0	5.6	11.0
Silver	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Strontium	0.08	0.10	0.09	0.20	0.26	1.80	2.60	1.10	0.29
Thallium	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Vanadium	1.10	0.94	0.45	0.42	0.50	0.88	1.60	0.41	2.00
Zinc	86.7	138.0	185.0	202.0	158.0	136.0	125.0	135.0	135.0

Table 6. Concentrations of inorganic trace elements in the livers of birds found dead during winter, 1988, at Monte Vista National Wildlife Refuge (site 1A).

	Great Blue Heron					Great Horned Owl		
Variable	a	b	c	d	e	a	b	c
Date Collected	1-2/88	1-2/88	1-2/88	1-2/88	1-2/88	1-2/88	1-2/88	1-2/88
Age	adult	adult	adult	adult	adult	adult	adult	adult
Sex	female	female	female	male	female	female	female	--
Percent Moisture	--	77.9	78.7	80.2	73.7	70.7	76.0	77.8
Arsenic	0.10	<0.03	0.11	0.12	<0.02	0.07	<0.02	0.08
Copper	268.0	93.5	62.9	335.0	83.7	11.3	38.3	38.3
Iron	12300.0	8610.0	4220.0	14100.0	9620.0	1030.0	1980.0	1680.0
Magnesium	752.0	896.0	657.0	808.0	989.0	580.0	708.0	540.0
Manganese	9.0	11.9	<7.0	14.1	11.4	11.9	16.2	7.2
Mercury	40.2	106.0	12.5	42.7	207.0	1.66	5.0	2.05
Selenium	19.5	45.8	13.6	24.7	81.0	4.1	9.2	3.6
Zinc	444.0	352.0	156.0	494.0	330.0	61.8	253.0	193.0

Table 6. (continued)

	Marsh Hawk			Mallard				
Variable	a	b	c	a	b	c	d	e
Date Collected	1-2/88	1-2/88	1-2/88	1/88	1/88	1/88	1/88	1/88
Age	adult	adult	adult	adult	juvenile	juvenile	juvenile	juvenile
Sex	female	female	female	male	female	female	male	male
Percent Moisture	74.8	70.8	70.8	74.5	72.1	71.4	71.8	75.1
Arsenic	0.03	0.07	0.05	0.07	0.08	0.09	0.06	0.09
Copper	13.9	23.3	50.0	347.0	100.0	14.0	68.8	69.1
Iron	1550.0	1580.0	2350.0	1760.0	4300.0	1150.0	3260.0	4500.0
Magnesium	833.0	856.0	890.0	706.0	717.0	594.0	674.0	643.0
Manganese	23.4	17.8	18.2	7.84	11.10	<5.24	6.74	8.43
Mercury	7.62	8.32	4.01	0.23	0.12	0.11	<0.09	0.11
Selenium	6.7	8.6	4.8	1.6	1.8	1.4	0.71	1.2
Zinc	342.0	247.0	370.0	109.0	126.0	58.7	101.0	87.6

Table 7. Concentrations of inorganic trace elements in the livers of mallards collected at Monte Vista NWR (site 1A) during the summer months, 1987-88.

Variable	a	b	c	d	e	f	g	h
Date Collected	07/21/87	07/21/87	7/88	7/88	7/88	7/88	7/88	7/88
Age	juvenile	juvenile	juvenile	juvenile	juvenile	juvenile	juvenile	juvenile
Sex	--	--	--	--	--	--	--	--
Percent Moisture	70.1	72.6	74.8	72.6	77.4	74.5	73.2	77.2
Arsenic	0.30	<0.2	0.13	0.24	0.64	0.32	0.37	0.27
Copper	16.5	16.5	143.0	71.9	<11.1	40.8	42.2	24.6
Iron	486.0	543.0	635.0	1950.0	3220.0	569.0	1050.0	1790.0
Magnesium	598.0	761.0	833.0	876.0	752.0	706.0	858.0	746.0
Manganese	6.7	15.0	12.7	12.8	10.2	13.7	15.7	24.1
Mercury	0.12	0.05	0.32	0.20	0.18	0.30	0.22	0.32
Selenium	4.5	4.3	7.1	10.9	10.6	1.6	9.0	13.6
Zinc	86.2	148.0	124.0	131.0	96.5	126.0	166.0	96.5

Table 8. Concentrations of inorganic trace elements in the livers of radio-collared mallards collected at Monte Vista NWR (site 1A) during winter, 1988.

Variable	a	b	c	d	e	f	g	h	i	j
Date Collected	2/88	2/88	2/88	2/88	2/88	2/88	2/88	2/88	2/88	2/88
Age	adult	adult	adult	adult	adult	adult	adult	adult	adult	adult
Sex	female	female	female	female	female	female	female	female	female	female
Percent Moisture	70.4	73.7	72.5	70.6	72.1	75.0	71.1	70.2	--	--
Arsenic	0.06	0.10	0.11	0.14	0.07	0.06	0.08	0.06	0.12	0.2
Copper	115.0	54.0	160.0	73.5	105.0	112.0	173.0	43.3	58.8	79.8
Iron	6660.0	5210.0	7300.0	4980.0	2360.0	4320.0	5220.0	2930.0	11300.0	5370.0
Magnesium	642.0	837.0	764.0	824.0	646.0	720.0	796.0	638.0	761.0	698.0
Manganese	9.5	14.1	15.6	14.0	9.5	11.2	14.9	13.1	13.8	9.9
Mercury	<0.08	0.11	0.21	0.15	0.48	0.10	0.10	0.10	0.10	<0.08
Selenium	1.4	1.1	2.5	2.5	2.0	1.6	2.1	1.7	0.7	1.8
Zinc	124.0	187.0	147.0	241.0	107.0	173.0	161.0	96.0	266.0	118.0

Table 9. Concentrations of inorganic trace elements in the livers of mallard ducks collected at Monte Vista NWR (site 1A) during winter, 1988.

Variable	a	b	c	d	e	f	g
Date Collected	1/88	1/88	1/88	1/88	1/88	1/88	1/88
Age	juvenile	juvenile	juvenile	juvenile	juvenile	juvenile	juvenile
Sex	female	female	female	female	female	female	female
Percent Moisture	72.2	73.6	71.9	73.3	72.3	71.0	74.3
Arsenic	0.08	0.08	0.11	0.12	0.11	1.17	0.09
Copper	267.0	55.3	60.1	118.0	125.0	175.0	128.0
Iron	1500.0	6440.0	6510.0	4490.0	3190.0	2830.0	5450.0
Magnesium	755.0	758.0	676.0	787.0	686.0	690.0	739.0
Manganese	10.8	12.1	10.0	14.2	14.8	7.9	14.4
Mercury	<0.09	<0.10	0.26	0.16	<0.09	0.22	0.15
Selenium	2.5	0.8	2.1	3.4	1.4	1.4	3.1
Zinc	147.0	383.0	102.0	138.0	106.0	112.0	129.0

Table 9. (continued)

Variable	h	i	j	k	l	m
Date Collected	1/88	1/88	1/88	1/88	1/88	1/88
Age	juvenile	juvenile	juvenile	juvenile	juvenile	juvenile
Sex	female	female	female	female	female	female
Percent Moisture	71.4	74.7	73.6	72.9	73.2	73.2
Arsenic	0.08	0.13	0.08	0.05	0.06	0.05
Copper	47.6	15.0	214.0	63.5	152.0	193.0
Iron	4580.0	1220.0	3070.0	2780.0	2190.0	2940.0
Magnesium	804.0	593.0	758.0	701.0	634.0	746.0
Manganese	8.4	<5.9	12.1	8.9	7.5	10.1
Mercury	<0.09	<0.10	0.10	0.14	<0.09	0.13
Selenium	1.4	2.0	0.8	1.5	1.1	2.2
Zinc	128.0	57.3	153.0	122.0	113.0	161.0

samples collected from various locations around the San Luis Valley.

Variable	3B	3G	3A	3F	3I	7	12	13
				Site Numbers				
Species	Black Bass	Black Bass	Rainbow Trout	Rainbow Trout	Rainbow Trout	Brook Trout	Brook Trout	Brook Trout
Date Collected	06/24/87	06/24/87	06/24/87	06/24/87	06/24/87	10/16/87	10/15/87	10/15/87
Number in Sample	1	2	3	4	3	10	10	10
Percent Moisture	69.2	73.4	75.0	72.2	70.0	74.6	79.0	76.8
Aluminum	6.0	46.0	5.0	61.0	20.0	160.0	491.0	89.0
Arsenic	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1
Barium	1.2	1.6	6.4	3.6	3.5	3.8	14.1	3.5
Beryllium	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.2	<0.2
Boron	<2.0	<2.0	<2.0	<2.0	<2.0	<4.0	<4.0	<4.0
Cadmium	<0.05	<0.04	0.05	0.05	<0.05	<0.3	<0.3	<0.3
Chromium	1.0	1.0	1.0	<0.9	1.0	<2.0	2.0	<2.0
Copper	0.9	1.2	15.0	4.8	2.5	2.6	3.0	2.2
Iron	56.9	113.0	149.0	117.0	76.3	301.0	1040.0	185.0
Lead	<0.5	<0.5	<0.5	<0.5	<0.5	<4.0	<4.0	<4.0
Magnesium	990.0	1120.0	1380.0	1280.0	1110.0	1200.0	1360.0	1180.0
Manganese	2.4	4.4	4.9	4.9	5.3	32.9	38.0	8.6
Mercury	0.39	0.39	0.78	0.58	0.21	0.25	0.23	0.11
Molybdenum	0.57	0.37	0.42	0.30	0.66	<1.0	<1.0	<1.0
Nickel	0.41	0.38	0.64	0.37	0.43	<2.0	<2.0	<2.0
Selenium	0.4	3.0	0.5	0.3	0.3	1.8	2.0	2.0
Silver	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<2.0	<2.0
Strontium	78.3	48.3	150.0	122.0	66.0	20.4	50.0	32.1
Thallium	<0.6	<0.7	<0.7	<0.7	<0.7	<4.0	<4.0	<4.0
Vanadium	0.06	0.26	0.21	0.55	0.52	1.0	1.0	<0.5
Zinc	46.4	51.8	153.0	108.0	52.3	88.1	136.0	85.8

Table 10. (continued)

Variable	24	10	11	16	22	25	26	1B
				Site Numbers				
Species	Brook Trout	Brown Trout	Brown Trout	Brown Trout	Brown Trout	Brown Trout	Brown Trout	White Sucker
Date Collected	10/14/87	10/16/87	10/14/87	10/15/87	10/14/87	10/13/87	10/13/87	10/15/87
Number in Sample	5	5	3	2	1	6	5	4
Percent Moisture	70.4	74.5	73.7	73.8	75.9	74.2	77.4	72.5
Aluminum	81.0	260.0	9.3	26.0	93.0	110.0	46.0	20.0
Arsenic	0.8	<0.4	0.3	<0.1	<0.1	<0.4	<0.1	0.2
Barium	1.3	5.4	0.9	0.8	0.6	2.8	2.6	3.4
Beryllium	0.3	0.3	0.3	0.3	0.3	0.2	0.3	<0.2
Boron	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0
Cadmium	<0.3	2.3	<0.3	<0.3	0.4	<0.3	<0.3	<0.3
Chromium	3.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Copper	5.7	15.0	8.2	5.8	3.8	7.7	10.0	2.6
Iron	231.0	388.0	105.0	76.0	198.0	190.0	161.0	127.0
Lead	<4.0	10.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0
Magnesium	1100.0	1200.0	980.0	897.0	967.0	1150.0	1220.0	1210.0
Manganese	15.0	39.5	3.7	3.5	2.5	15.0	18.0	9.7
Mercury	0.35	0.15	0.19	2.00	0.21	0.21	0.47	0.49
Molybdenum	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nickel	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Selenium	1.8	1.3	1.9	1.1	2.6	1.3	1.5	1.2
Silver	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Strontium	27.4	33.1	16.5	15.0	9.3	22.8	13.0	51.9
Thallium	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0
Vanadium	0.8	0.8	<0.5	<0.5	0.6	0.6	0.7	<0.5
Zinc	136.0	197.0	88.1	126.0	69.1	95.6	119.0	55.9

Table 10. (continued)

Variable	1B	4A	5A	5B	16	17	24	26
				Site Numbers				
Species	White Sucker	White Sucker	White Sucker	White Sucker	White Sucker	White Sucker	White Sucker	White Sucker
Date Collected	10/15/87	06/23/87	06/22/87	06/22/87	10/15/87	10/15/87	10/14/87	10/13/87
Number in Sample	5	1	5	2	5	5	1	5
Percent Moisture	69.9	72.9	74.1	76.0	75.0	73.1	66.3	76.2
Aluminum	19.0	14.0	46.0	56.0	120.0	110.0	81.0	220.0
Arsenic	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Barium	2.5	5.6	30.2	12.7	4.7	3.9	3.3	11.8
Beryllium	<0.2	<0.1	<0.1	<0.1	<0.2	<0.2	<0.2	<0.2
Boron	<4.0	<2.0	<2.0	<2.0	<4.0	<4.0	<4.0	<4.0
Cadmium	<0.3	<0.04	<0.04	0.04	<0.3	<0.3	<0.3	<0.3
Chromium	<2.0	<0.9	1.0	2.0	<2.0	<2.0	<2.0	2.0
Copper	2.1	3.8	3.2	4.0	4.2	2.5	3.8	3.4
Iron	93.0	73.1	149.0	127.0	258.0	198.0	196.0	519.0
Lead	<4.0	<0.5	<0.5	<0.5	<4.0	<4.0	<4.0	<4.0
Magnesium	940.0	1290.0	1560.0	1320.0	1230.0	1050.0	1160.0	1410.0
Manganese	10.0	19.0	7.7	11.0	45.5	12.0	24.0	65.2
Mercury	0.33	0.13	0.16	0.05	0.65	0.20	0.76	0.68
Molybdenum	<1.0	0.55	0.45	0.40	<1.0	<1.0	<1.0	<1.0
Nickel	<2.0	2.30	0.42	0.42	<2.0	<2.0	<2.0	<2.0
Selenium	0.9	1.0	1.5	1.1	0.9	0.6	0.9	0.9
Silver	<2.0	<1.0	<1.0	<1.0	<2.0	<2.0	<2.0	<2.0
Strontium	30.1	95.0	119.0	61.4	34.4	28.2	41.3	41.6
Thallium	<4.0	<0.7	<0.7	<0.6	<4.0	<4.0	<4.0	<4.0
Vanadium	<0.5	0.13	0.57	0.41	0.9	0.7	0.5	1.5
Zinc	40.0	61.8	75.4	48.7	57.1	48.1	66.6	69.9

Table 10. (continued)

Variable	27	1A	1B	2A	5A	5B	5B	4B
				Site Numbers				
Species	White Sucker	Common Carp	Common Carp	Common Carp	Common Carp	Common Carp	Common Carp	Fathead Minnow
Date Collected	10/13/87	08/15/86	10/15/87	08/15/86	06/22/87	06/22/87	06/22/87	06/22/87
Number in Sample	5	1	4	4	5	5	4	--
Percent Moisture	75.6	72.5	74.0	79.0	77.9	77.5	75.0	84.0
Aluminum	441.0	256.0	29.0	263.5	110.0	33.0	120.0	81.0
Arsenic	<0.1	0.1	0.2	0.6	<0.1	0.3	<0.1	0.3
Barium	9.0	--	4.3	--	48.0	33.8	28.6	11.4
Beryllium	<0.2	<0.01	<0.2	<0.01	<0.1	<0.1	<0.1	<0.1
Boron	<4.0	--	<4.0	--	<2.0	<2.0	<2.0	2.0
Cadmium	<0.3	<0.03	<0.3	0.07	0.1	0.07	0.06	0.1
Chromium	2.0	0.7	<2.0	1.4	<0.9	1.0	<0.9	<0.9
Copper	5.6	3.8	4.8	5.8	4.5	4.6	3.5	3.9
Iron	938.0	74.5	127.0	370.5	243.0	165.0	201.0	248.0
Lead	<4.0	<0.4	<4.0	<0.4	<0.5	<0.5	<0.5	<0.5
Magnesium	1350.0	--	1080.0	--	1530.0	1480.0	1440.0	1600.0
Manganese	45.3	29.6	7.8	37.3	10.0	8.5	11.0	16.0
Mercury	0.41	0.40	0.31	0.58	0.21	0.14	0.13	0.47
Molybdenum	<1.0	--	<1.0	--	0.10	0.30	0.20	0.20
Nickel	<2.0	0.41	<2.0	0.56	0.39	0.30	0.30	2.30
Selenium	2.0	1.1	0.9	0.4	1.9	1.6	1.4	1.3
Silver	<2.0	--	<2.0	--	<1.0	<1.0	<1.0	<1.0
Strontium	40.7	--	60.8	--	137.0	149.0	147.0	104.0
Thallium	<4.0	<0.8	<4.0	<0.9	<0.7	<1.0	<0.7	<0.7
Vanadium	2.5	--	0.5	--	1.20	0.89	0.79	0.67
Zinc	58.1	144.0	237.0	188.0	283.0	286.0	270.0	163.0

Table 10. (continued)

Variable	Site Numbers 17	18	27	5A	5B	25	1B	16
Species	Fathead Minnow	Fathead Minnow	Fathead Minnow	Brown Bullhead	Brown Bullhead	Longnose Dace	Northern Pike	Rio Grande Chub
Date Collected	10/15/87	10/15/87	10/13/87	06/22/87	06/22/87	10/13/87	10/15/87	10/15/87
Number in Sample	11	12	30	5	5	22	3	25
Percent Moisture	78.3	76.7	76.7	82.0	80.8	78.1	71.4	72.8
Aluminum	2060.0	40.0	4030.0	48.0	54.0	19.0	47.0	42.0
Arsenic	1.3	0.4	1.4	<0.1	<0.1	<0.1	<0.1	<0.1
Barium	59.8	13.2	78.7	19.5	14.2	12.0	1.0	8.1
Beryllium	0.3	<0.2	0.4	<0.1	<0.1	<0.2	<0.2	<0.2
Boron	<4.0	<4.0	<4.0	7.5	<2.0	<4.0	<4.0	<4.0
Cadmium	<0.3	<0.3	<0.3	0.05	<0.04	<0.3	<0.3	<0.3
Chromium	4.0	<2.0	8.5	1.0	<0.9	<2.0	<2.0	<2.0
Copper	8.2	4.3	11.0	2.6	2.2	5.0	7.2	3.5
Iron	2630.0	167.0	4740.0	194.0	152.0	84.0	108.0	111.0
Lead	13.0	<4.0	<4.0	<0.5	<0.5	<4.0	<4.0	<4.0
Magnesium	2110.0	1310.0	2170.0	1500.0	1360.0	1240.0	1030.0	1300.0
Manganese	71.6	10.0	140.0	11.0	12.0	20.0	5.0	14.0
Mercury	0.17	0.30	0.19	0.19	0.23	0.26	0.71	0.87
Molybdenum	<1.0	<1.0	<1.0	0.20	0.30	<1.0	<1.0	<1.0
Nickel	3.00	<2.0	5.00	0.30	0.30	<2.0	<2.0	<2.0
Selenium	1.6	4.7	3.6	3.8	1.7	1.9	1.5	1.1
Silver	<2.0	<2.0	<2.0	<1.0	<1.0	<2.0	<2.0	<2.0
Strontium	79.0	62.6	87.5	87.1	87.6	66.7	14.0	53.2
Thallium	<5.0	<4.0	<4.0	<0.7	<0.7	<4.0	<4.0	<4.0
Vanadium	7.1	1.0	9.9	0.50	0.33	<0.5	<0.5	<0.5
Zinc	220.0	164.0	172.0	70.0	67.3	103.0	139.0	138.0

Table 11. Concentrations of mercury and selenium in muscle tissues of fish from the Rio Grande River at Alamosa NWR (site 2B-County Line) and Labota Bridge (site 29). Samples were collected on 10/26/89.

Species	Site Number	Fresh Weight(g)	Mercury wet wt. conc.	Mercury dry wt. conc.	Selenium wet wt. conc.	Selenium dry wt. conc.
Northern Pike	2B	319	0.29	1.40	0.24	1.10
Northern Pike	2B	254	0.45	2.10	0.19	0.92
Northern Pike	2B	133	0.30	1.40	0.16	0.76
Northern Pike	29	98	0.10	0.51	0.21	1.10
Northern Pike	29	61	0.09	0.47	0.18	0.90
Northern Pike	29	74	0.11	0.58	0.21	1.10
Rio Grande Sucker	2B	104	0.27	1.40	0.26	1.40
Rio Grande Sucker	2B	89	0.19	0.93	0.28	1.40
Rio Grande Sucker	2B	109	0.11	0.59	0.28	1.40
Rio Grande Sucker	29	67	0.23	1.40	0.22	1.40
Rio Grande Sucker	29	44	0.38	2.30	0.19	1.10
Rio Grande Sucker	29	61	0.21	1.10	0.19	1.10
Common Carp	2B	288	0.03	0.18	0.11	0.62
Common Carp	2B	227	0.04	0.20	0.16	0.81
Common Carp	2B	344	0.28	1.20	0.19	0.87
Common Carp	29	244	0.34	1.70	0.20	1.00
Common Carp	29	175	0.25	1.40	0.20	1.20
Common Carp	29	166	0.29	1.60	0.25	1.40

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Table 12. Concentrations of mercury and selenium in fish tissues from San Luis Lake (site 4A).

Species	Tissue Type	Date	Fresh Weight(g)	Mercury wet wt. conc.	Mercury dry wt. conc.	Selenium wet wt. conc.	Selenium dry wt. conc.
Rainbow Trout	Muscle	02/19/89	98	0.03	0.12	0.35	1.50
Rainbow Trout	Muscle	02/19/89	102	0.04	0.19	0.23	1.00
Rainbow Trout	Muscle	02/19/89	104	0.03	0.10	0.20	0.76
Rainbow Trout	Muscle	02/19/89	102	0.03	0.11	0.06	0.27
Rainbow Trout	Muscle	07/15/88	95	0.03	0.10	0.10	0.34
Rainbow Trout	Muscle	07/15/88	103	<0.03	<0.10	0.14	0.51
Rainbow Trout	Muscle	06/09/89	1175	0.05	0.19	0.21	0.81
Rainbow Trout	Muscle	06/09/89	1460	0.05	0.17	0.21	0.74
Rainbow Trout	Muscle	06/09/89	1060	0.06	0.27	0.19	0.78
Rainbow Trout	Muscle	06/09/89	1120	0.05	0.19	0.18	0.74
Rio Grande Sucker	Muscle	06/09/89	436	0.09	0.38	0.19	0.79
Rio Grande Sucker	Muscle	06/09/89	410	0.04	0.17	0.10	0.60
Rainbow Trout	Liver	02/19/89	100	0.03	0.11	2.79	12.04
Rainbow Trout	Liver	02/19/89	61	0.04	0.17	2.19	8.63
Rainbow Trout	Kidney	02/19/89	78	0.03	0.11	0.69	2.92
Rainbow Trout	Kidney	02/19/89	53	0.05	0.22	0.98	4.05

Table 13. Concentrations of inorganic trace elements in aquatic invertebrate samples from rivers and tributary streams around the San Luis Valley.

Variable	Site Numbers 8	10	11	18	24	25	26
Date Collected	10/16/87	10/16/87	10/14/87	10/15/87	10/14/87	10/13/87	10/13/87
Percent Moisture	90.1	83.8	88.4	88.5	98.6	91.9	96.0
Aluminum	1870.0	3510.0	1570.0	452.0	2440.0	3980.0	4850.0
Arsenic	2.30	2.90	0.48	1.90	0.66	1.30	0.76
Barium	46.1	59.3	45.8	103.0	25.5	83.8	113.0
Beryllium	<0.2	<0.2	<0.2	<0.2	<0.2	0.30	0.20
Boron	<5.0	<7.0	<5.0	6.0	<5.0	<5.0	<5.0
Cadmium	0.4	6.2	5.6	<0.3	1.0	0.9	0.3
Chromium	16.0	3.0	8.7	9.6	<1.0	7.1	9.3
Copper	36.9	37.0	15.0	37.7	24.0	26.0	25.0
Iron	3690.0	4800.0	1960.0	1080.0	3820.0	8030.0	8530.0
Lead	<4.0	67.0	13.0	<4.0	<4.0	<5.0	<4.0
Magnesium	1840.0	2540.0	1310.0	1750.0	1940.0	2390.0	2150.0
Manganese	738.0	634.0	132.0	91.0	422.0	551.0	984.0
Mercury	0.04	0.04	0.11	0.18	0.11	0.13	0.13
Molybdenum	<1.0	<2.0	<1.0	<1.0	<1.0	<2.0	<2.0
Nickel	8.0	<3.0	5.0	4.0	<3.0	5.0	5.0
Selenium	0.82	0.62	2.00	1.20	1.40	0.69	0.40
Silver	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Strontium	23.9	30.4	17.0	338.0	28.0	33.3	28.4
Thallium	<4.0	<5.0	<4.0	<4.0	<4.0	<5.0	<5.0
Vanadium	9.0	10.0	5.0	4.6	8.1	19.0	19.0
Zinc	175.0	1070.0	292.0	63.7	354.0	161.0	109.0

Table 14. Concentrations of inorganic trace elements in aquatic plant samples collected from various locations around the San Luis Valley.

Variable	1A	1A	1B	2A	3A	3B	3D
	Site Numbers						
Species	Pondweed	Pondweed	--	Pondweed	Milfoil	Ranuncul.	Milfoil
Date Collected	08/15/86	08/15/86	10/15/87	08/15/86	06/24/87	06/24/87	06/24/87
Percent Moisture	91.1	87.8	81.6	84.4	93.5	92.9	86.2
Aluminum	1180.0	151.0	15800.0	981.0	5690.0	4720.0	431.0
Arsenic	1.4	0.3	2.9	0.7	4.9	1.6	3.7
Barium	--	--	219.0	--	103.0	77.7	87.2
Beryllium	0.10	0.02	1.10	0.06	0.30	0.30	<0.1
Boron	--	--	51.0	--	18.0	100.0	28.0
Cadmium	0.26	0.13	0.7	0.09	0.29	0.37	0.29
Chromium	1.4	<0.2	24.0	0.2	23.0	4.9	6.2
Copper	3.6	1.9	23.0	2.7	8.4	7.7	10.2
Iron	1030.0	229.0	15800.0	1200.0	7760.0	6060.0	1170.0
Lead	1.0	0.7	10.0	<0.5	1.0	0.8	<0.5
Magnesium	--	--	5020.0	--	3090.0	3310.0	1860.0
Manganese	288.0	450.0	2370.0	3970.0	504.0	318.0	304.0
Mercury	0.08	0.07	0.04	0.08	0.03	0.01	0.02
Molybdenum	--	--	<2.0	--	5.7	2.8	4.9
Nickel	1.8	0.5	13.0	0.5	11.0	2.6	2.3
Selenium	0.79	0.20	1.40	0.30	<0.1	<0.1	<0.1
Silver	--	--	<2.0	--	<1.0	<1.0	<1.0
Strontium	--	--	312.0	--	137.0	149.0	352.0
Thallium	<1.0	<0.9	<5.0	<1.0	<1.0	<1.0	<0.7
Vanadium	--	--	32.0	--	20.6	15.9	11.3
Zinc	19.2	13.7	73.3	10.8	34.7	28.4	32.8

Table 14. (continued)

Variable	3F	3G	3I	4C	4D	5A	5B
	Site Numbers						
Species	Milfoil	Milfoil	Potomog.	F. Algae	F. Algae	Chara sp.	Chara sp.
Date Collected	06/24/87	06/24/87	06/24/87	06/22/87	06/22/87	06/22/87	06/22/87
Percent Moisture	93.3	96.1	87.7	85.8	67.8	90.7	94.4
Aluminum	230.0	356.0	190.0	6300.0	6790.0	1280.0	1440.0
Arsenic	0.5	1.7	0.9	2.1	1.9	3.2	6.5
Barium	40.8	49.7	29.0	216.0	110.0	640.0	2510.0
Beryllium	<0.1	<0.1	<0.1	0.37	0.55	<0.1	<0.1
Boron	449.0	26.0	20.0	22.0	9.9	56.0	6.0
Cadmium	0.18	0.40	0.28	0.43	0.60	0.09	0.10
Chromium	3.3	2.9	<0.9	5.1	8.5	2.0	2.8
Copper	3.7	1.9	9.5	12.0	7.9	2.6	3.2
Iron	363.0	642.0	277.0	8090.0	16800.0	1460.0	1280.0
Lead	<0.5	<0.5	<0.5	11.0	16.0	0.8	0.8
Magnesium	5630.0	1220.0	1700.0	3130.0	2740.0	3220.0	3570.0
Manganese	220.0	200.0	125.0	4410.0	1010.0	86.1	89.4
Mercury	0.04	0.02	0.01	0.05	0.01	0.01	0.01
Molybdenum	2.8	2.1	2.6	1.0	2.0	0.5	0.2
Nickel	1.1	1.4	0.4	7.1	12.2	1.1	1.9
Selenium	<0.1	0.87	<0.1	0.67	<0.01	0.30	0.30
Silver	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Strontium	231.0	214.0	160.0	113.0	61.0	536.0	755.0
Thallium	<0.7	<0.7	<0.7	<1.0	<2.0	<0.8	<0.8
Vanadium	5.8	9.5	12.5	14.8	42.7	8.5	9.6
Zinc	29.2	15.4	64.6	90.3	83.7	14.3	18.8

Table 14. (continued)

Variable	Site Numbers 7	9	10	11	15	16	18
Species	--	--	--	--	--	--	--
Date Collected	10/16/87	10/16/87	10/16/87	10/14/87	10/15/87	10/15/87	10/15/87
Percent Moisture	91.4	88.6	87.5	92.2	92.5	84.8	92.8
Aluminum	13700.0	12400.0	1300.0	2740.0	24900.0	10600.0	3790.0
Arsenic	2.4	100.0	0.6	1.2	20.0	2.9	13.0
Barium	141.0	506.0	68.5	59.9	1220.0	148.0	106.0
Beryllium	1.20	3.10	0.40	0.50	3.10	1.10	0.87
Boron	100.0	<4.0	<4.0	9.0	20.0	7.0	57.0
Cadmium	<0.3	59.9	8.4	0.3	40.6	<0.3	0.3
Chromium	54.0	5.0	7.8	3.0	13.0	14.0	45.0
Copper	13.0	176.0	17.0	5.3	696.0	9.8	38.8
Iron	19900.0	15200.0	1680.0	5120.0	31500.0	12700.0	10500.0
Lead	10.0	3050.0	18.0	<4.0	300.0	6.0	<4.0
Magnesium	4290.0	2980.0	5390.0	2330.0	5100.0	3750.0	3590.0
Manganese	946.0	2520.0	374.0	489.0	43400.0	589.0	1550.0
Mercury	0.02	0.07	0.02	0.03	0.08	0.02	0.03
Molybdenum	<2.0	4.0	<1.0	2.0	4.0	<2.0	2.0
Nickel	24.0	6.0	5.0	3.0	44.0	7.8	20.0
Selenium	<0.2	0.20	0.40	0.69	1.30	<0.2	2.00
Silver	<2.0	10.0	<2.0	<2.0	9.4	<2.0	<2.0
Strontium	73.9	41.2	92.9	52.5	186.0	80.4	88.5
Thallium	7.0	<5.0	<5.0	<5.0	<6.0	8.0	6.0
Vanadium	48.0	26.0	4.0	12.0	38.0	28.0	50.0
Zinc	69.2	17400.0	1060.0	52.8	12700.0	43.0	36.0

Table 14. (continued)

Variable	Site Numbers 18	19	23	24	25	26	27
Species	--	--	--	--	--	--	--
Date Collected	10/15/87	10/14/87	10/14/87	10/14/87	10/13/87	10/13/87	10/13/87
Percent Moisture	86.8	91.7	76.9	90.3	90.5	95.8	92.2
Aluminum	1340.0	20300.0	92200.0	19600.0	1690.0	8740.0	14100.0
Arsenic	4.9	4.0	28.0	9.7	1.0	1.8	2.1
Barium	108.0	671.0	248.0	253.0	78.7	80.8	196.0
Beryllium	0.70	1.40	11.00	1.20	0.40	0.74	0.98
Boron	518.0	<4.0	<4.0	<4.0	6.0	15.0	10.0
Cadmium	<0.4	1.0	9.1	0.3	0.6	<0.3	0.4
Chromium	12.0	7.5	6.7	7.0	8.2	17.0	12.0
Copper	5.7	21.0	5570.0	25.0	7.0	20.0	47.5
Iron	4630.0	111000.0	128000.0	27700.0	3030.0	10200.0	12600.0
Lead	<4.0	6.0	69.0	6.0	<4.0	<4.0	10.0
Magnesium	1980.0	3360.0	2870.0	4090.0	2580.0	2820.0	5080.0
Manganese	1730.0	2700.0	607.0	1720.0	990.0	2090.0	889.0
Mercury	0.03	0.10	0.19	0.04	0.02	0.06	0.06
Molybdenum	4.0	10.0	20.0	<3.0	1.0	3.0	<2.0
Nickel	6.0	8.4	43.0	4.0	4.0	11.0	9.4
Selenium	1.40	1.10	<0.2	0.30	<0.2	0.50	0.50
Silver	<2.0	<3.0	<3.0	<2.0	<2.0	<2.0	<2.0
Strontium	81.7	153.0	129.0	124.0	70.1	64.8	1.9
Thallium	<5.0	<5.0	<5.0	7.0	<5.0	<5.0	<5.0
Vanadium	33.0	47.0	53.0	56.7	8.9	21.0	25.0
Zinc	17.0	104.0	2030.0	93.0	52.0	39.0	60.2

Table 15. Concentrations of inorganic trace elements in zooplankton samples collected from the San Luis Lakes system in the San Luis Valley.

Variable	4A	4B	4C	4D
	Site Numbers			
Date Collected	06/22/87	06/22/87	06/22/87	06/22/87
Percent Moisture	92.3	95.1	95.6	96.8
Aluminum	374.0	1210.0	5800.0	2920.0
Arsenic	0.8	0.7	2.2	4.8
Barium	9.7	21.3	78.4	29.4
Beryllium	<0.1	<0.1	<0.2	<0.2
Boron	5.0	4.0	62.0	28.0
Cadmium	0.45	0.49	0.77	0.71
Chromium	<0.9	2.0	7.1	3.0
Copper	5.3	7.4	13.6	9.1
Iron	530.0	1460.0	7930.0	4350.0
Lead	<0.5	<0.5	<1.0	3.0
Magnesium	1460.0	1910.0	9010.0	6760.0
Manganese	52.1	219.0	713.0	309.0
Mercury	0.26	0.28	2.20	2.35
Molybdenum	0.4	0.4	2.2	1.6
Nickel	0.6	1.1	68.4	1.9
Selenium	1.7	1.9	0.4	1.2
Silver	<1.0	<1.0	<2.0	<2.0
Strontium	177.0	199.0	329.0	475.0
Thallium	<0.7	<0.8	<2.0	<2.0
Vanadium	1.0	4.2	17.7	9.6
Zinc	58.8	71.8	71.4	65.7

Table 16. Concentrations of inorganic trace elements in sediment samples from various locations around the San Luis Valley.

Variable	1A	1A	1B	2A	3A	3B	3D
			Site Numbers				
Date Collected	08/15/86	08/15/86	10/15/87	08/15/86	06/24/87	06/24/87	06/24/87
Percent Moisture	60.1	33.7	52.2	35.9	17.9	24.0	43.1
Aluminum	7750.0	5030.0	15500.0	10100.0	3920.0	3780.0	6110.0
Arsenic	3.8	3.0	2.7	2.1	0.71	0.59	0.90
Barium	131.0	94.9	178.0	190.0	53.5	59.7	53.7
Beryllium	0.58	0.34	0.98	0.91	0.39	0.37	0.57
Boron	7.5	5.0	<4.0	<2.0	<2.0	<2.0	3.0
Cadmium	<0.2	<0.2	0.4	0.8	<0.2	<0.2	<0.2
Chromium	11.0	11.0	9.9	6.5	4.0	3.6	6.8
Copper	21.0	10.0	25.0	14.0	4.3	4.5	7.3
Iron	12000.0	9260.0	20300.0	17900.0	10500.0	9210.0	14300.0
Lead	10.0	8.0	10.0	50.0	<4.0	<4.0	<4.0
Magnesium	7500.0	4970.0	5270.0	3410.0	1810.0	2660.0	3960.0
Manganese	382.0	171.0	351.0	571.0	130.0	138.0	188.0
Mercury	0.03	<0.02	0.04	0.03	0.03	<0.03	<0.03
Molybdenum	1.0	<0.8	<3.0	<1.0	<2.0	<2.0	<2.0
Nickel	8.4	7.0	8.0	5.6	<2.0	<2.0	3.0
Selenium	0.20	<0.1	0.57	0.10	<0.1	<0.1	<0.1
Silver	<0.3	<0.3	<2.0	<0.3	<1.0	<1.0	<1.0
Strontium	227.0	171.0	175.0	58.4	37.7	46.6	52.8
Thallium	<8.0	<8.0	<6.0	<8.0	<4.0	<4.0	<4.0
Vanadium	46.8	25.0	32.0	26.0	17.0	14.0	25.0
Zinc	37.5	24.6	86.1	172.0	20.0	19.0	28.0

Table 16. (continued)

Variable	3F	3G	3I	4A	4B	5B	6
	Site Numbers						
Date Collected	06/24/87	06/24/87	06/24/87	06/22/87	06/22/87	06/22/87	10/16/87
Percent Moisture	25.2	25.9	39.3	24.9	25.4	39.3	49.9
Aluminum	2840.0	5600.0	12000.0	3020.0	4490.0	2740.0	13500.0
Arsenic	[illegible]	1.30	0.98	0.97	2.60	2.50	0.96
Barium	44.5	82.3	103.0	49.0	63.4	235.0	114.0
Beryllium	0.32	0.44	1.00	0.34	0.52	0.33	1.20
Boron	2.0	4.0	<2.0	2.0	2.0	3.0	<4.0
Cadmium	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.3
Chromium	3.4	4.4	12.0	6.7	7.6	5.9	6.0
Copper	3.5	6.1	22.0	5.3	7.4	4.7	14.0
Iron	8380.0	12000.0	25000.0	10500.0	15800.0	4550.0	16200.0
Lead	<4.0	<4.0	5.0	5.0	<4.0	<4.0	8.0
Magnesium	2110.0	3770.0	4640.0	3140.0	5190.0	3770.0	2950.0
Manganese	112.0	237.0	346.0	155.0	255.0	109.0	379.0
Mercury	0.03	<0.03	0.03	<0.03	<0.03	<0.03	0.41
Molybdenum	<2.0	<2.0	<3.0	<2.0	<2.0	<1.0	<2.0
Nickel	<2.0	3.0	8.9	2.0	3.0	2.0	4.0
Selenium	<0.1	<0.01	<0.1	<0.01	<0.01	<0.01	0.38
Silver	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0
Strontium	38.3	110.0	62.1	67.9	119.0	336.0	43.3
Thallium	<4.0	<4.0	<4.0	<4.0	<4.0	<3.0	8.0
Vanadium	16.0	23.0	45.3	19.0	37.3	19.0	31.0
Zinc	15.0	27.0	49.5	25.0	25.0	11.0	59.9

Table 16. (continued)

Variable	7	8	9	10	11	12	13
	Site Numbers						
Date Collected	10/16/87	10/16/87	10/16/87	10/16/87	10/14/87	10/15/87	10/15/87
Percent Moisture	46.6	30.3	47.9	34.3	56.6	27.6	46.5
Aluminum	25800.0	12200.0	8080.0	8590.0	11900.0	9250.0	23400.0
Arsenic	2.1	2.9	130.0	30.0	2.4	2.7	2.1
Barium	224.0	145.0	671.0	144.0	207.0	222.0	302.0
Beryllium	1.20	0.94	1.40	1.30	1.00	1.10	1.90
Boron	<4.0	<4.0	<4.0	<4.0	<5.0	<4.0	<4.0
Cadmium	<0.3	<0.3	44.1	5.3	<0.5	0.3	0.4
Chromium	10.0	5.0	2.0	9.1	5.6	5.0	7.0
Copper	19.0	9.4	119.0	19.0	8.1	9.7	23.0
Iron	29400.0	19700.0	16200.0	33700.0	13300.0	22300.0	21500.0
Lead	10.0	8.0	2950.0	300.0	9.0	15.0	19.0
Magnesium	7320.0	3170.0	2920.0	2580.0	3840.0	2680.0	4520.0
Manganese	568.0	496.0	2760.0	860.0	346.0	1040.0	767.0
Mercury	0.02	<0.01	0.19	0.02	0.01	0.01	0.05
Molybdenum	<3.0	<2.0	5.0	<4.0	<2.0	<3.0	<3.0
Nickel	7.0	<3.0	<3.0	3.0	<4.0	7.0	8.0
Selenium	<0.1	<0.1	0.20	<0.1	0.40	0.20	0.57
Silver	<2.0	<2.0	8.0	<2.0	<2.0	<2.0	<2.0
Strontium	95.4	64.2	33.6	42.5	60.0	43.6	89.1
Thallium	10.0	10.0	<6.0	10.0	6.0	<5.0	<6.0
Vanadium	45.0	41.0	26.0	89.5	26.0	22.0	41.0
Zinc	88.2	61.5	9690.0	755.0	45.0	61.0	86.2

Table 16. (continued)

Variable	14	15	16	17	18	19	20
	Site Numbers						
Date Collected	10/15/87	10/15/87	10/15/87	10/15/87	10/15/87	10/14/87	10/14/87
Percent Moisture	49.3	26.6	37.8	35.4	34.0	22.4	28.7
Aluminum	16800.0	10300.0	8630.0	8100.0	5970.0	10700.0	10300.0
Arsenic	21.0	11.0	1.9	2.6	3.1	2.1	39.0
Barium	330.0	356.0	146.0	157.0	79.4	184.0	287.0
Beryllium	2.60	1.50	0.87	0.78	0.62	1.10	0.90
Boron	<4.0	<4.0	<4.0	<4.0	<4.0	<5.0	<5.0
Cadmium	17.0	9.5	<0.3	0.7	<0.3	<0.5	<0.5
Chromium	7.4	6.0	7.8	9.4	7.2	6.6	4.0
Copper	1250.0	214.0	6.7	11.0	4.8	20.0	124.0
Iron	29900.0	21700.0	14200.0	14900.0	11500.0	33600.0	45600.0
Lead	250.0	180.0	<4.0	50.0	<4.0	10.0	75.0
Magnesium	3610.0	3000.0	3070.0	3150.0	2650.0	2340.0	1620.0
Manganese	3040.0	5490.0	435.0	237.0	179.0	1620.0	483.0
Mercury	0.05	0.04	<0.01	<0.02	<0.01	0.05	0.13
Molybdenum	<3.0	<3.0	<2.0	<2.0	<2.0	<4.0	<4.0
Nickel	10.0	11.0	3.0	5.0	<3.0	7.0	6.0
Selenium	0.45	0.20	<0.1	<0.1	0.10	<0.1	0.48
Silver	4.0	2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Strontium	38.4	51.5	59.4	48.8	56.3	66.6	66.3
Thallium	<6.0	<6.0	10.0	<6.0	6.0	<4.0	<4.0
Vanadium	36.0	29.0	29.0	34.0	31.0	34.0	29.0
Zinc	4200.0	2750.0	33.0	147.0	24.0	66.0	111.0

Table 16. (continued)

Variable	21	22	23	24	25	26	27
	Site Numbers						
Date Collected	10/14/87	10/14/87	10/14/87	10/14/87	10/13/87	10/13/87	10/13/87
Percent Moisture	34.3	32.4	24.2	20.9	24.4	21.3	40.3
Aluminum	15300.0	35000.0	20400.0	16200.0	12400.0	6680.0	17600.0
Arsenic	5.7	6.4	9.9	11.0	3.0	0.9	6.3
Barium	384.0	231.0	221.0	110.0	94.4	109.0	242.0
Beryllium	0.79	1.60	1.40	0.95	1.20	0.89	1.30
Boron	<5.0	<5.0	<5.0	<5.0	<5.0	<4.0	<4.0
Cadmium	<0.5	<0.5	0.7	<0.5	<0.5	<0.3	0.4
Chromium	3.0	4.0	7.2	6.2	8.7	10.0	7.7
Copper	16.0	55.4	391.0	12.0	11.0	8.0	43.4
Iron	55200.0	67400.0	39500.0	31400.0	31900.0	25800.0	30300.0
Lead	19.0	10.0	23.0	7.0	5.0	5.0	22.0
Magnesium	6380.0	4710.0	5090.0	3880.0	3400.0	2360.0	4690.0
Manganese	363.0	886.0	646.0	588.0	541.0	506.0	682.0
Mercury	0.09	0.05	0.06	<0.01	<0.01	0.01	0.06
Molybdenum	7.0	8.0	<4.0	<3.0	<3.0	<3.0	<3.0
Nickel	<4.0	8.0	10.0	<4.0	9.0	7.0	10.0
Selenium	1.90	0.52	0.93	<0.1	<0.1	<0.1	0.51
Silver	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Strontium	39.4	71.4	75.7	91.5	78.0	35.9	87.6
Thallium	<4.0	<4.0	<4.0	10.0	20.0	10.0	<6.0
Vanadium	49.0	58.0	48.0	68.4	82.4	67.6	48.0
Zinc	51.4	133.0	199.0	73.7	67.1	50.4	86.1

Table 17. Concentrations of inorganic trace elements in water samples from rivers and tributary streams around the San Luis Valley.

Variable	12	14	15	19	20	21	22	23
	Site Numbers							
Date Collected	10/15/87	10/15/87	10/15/87	10/14/87	10/14/87	10/14/87	10/14/87	10/14/87
Percent Moisture	--	--	--	--	--	--	--	--
Aluminum	0.320	0.910	<0.03	0.500	21.400	8.270	2.400	1.200
Arsenic	<0.002	0.002	0.002	<0.002	0.014	<0.002	<0.002	<0.002
Barium	0.042	0.030	0.038	0.044	0.092	0.016	0.025	0.036
Beryllium	<0.002	<0.002	<0.002	<0.002	0.004	<0.002	<0.002	<0.002
Boron	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium	<0.003	0.024	<0.003	<0.003	0.018	<0.003	<0.003	<0.003
Chromium	<0.01	<0.01	<0.01	0.030	<0.01	<0.01	<0.01	<0.01
Copper	<0.002	0.464	0.004	0.007	4.940	0.009	0.006	0.079
Iron	0.370	3.650	0.150	2.560	19.800	15.200	2.820	1.090
Lead	<0.04	<0.04	<0.04	<0.04	0.060	<0.04	<0.04	<0.04
Magnesium	2.300	6.950	11.600	2.560	13.600	10.900	3.860	6.740
Manganese	0.019	5.290	0.170	0.082	5.970	1.320	0.210	0.320
Mercury	0.0003	0.0003	0.0003	0.0003	0.0004	0.0003	0.0004	0.0003
Molybdenum	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nickel	<0.03	<0.03	<0.03	<0.03	0.083	<0.03	<0.03	<0.03
Selenium	<0.0004	<0.0004	<0.0004	<0.0004	0.0010	0.0010	<0.0004	0.0006
Silver	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Strontium	0.140	0.243	0.379	0.070	0.404	0.160	0.180	0.350
Thallium	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Vanadium	<0.007	<0.007	<0.007	<0.007	0.009	<0.007	<0.007	<0.007
Zinc	<0.003	7.060	0.100	0.190	2.390	0.140	0.023	0.098

Table 18. Concentrations of organochlorines in American coot whole bodies and livers from the San Luis Valley.

Variable	1A	1A	1A	2A	2A
			Site Numbers		
Matrix	Body	Body	Body	Body	Body
Collection Date	08/15/86	08/15/86	08/15/86	08/15/86	08/15/86
Percent Moisture	72.0	73.6	70.6	74.2	72.8
p,p'-DDD	ND	ND	ND	ND	ND
p,p'-DDE	0.02	0.01	0.01	0.01	0.02
Dieldrin	ND	ND	ND	ND	ND
Oxy-chlordane	ND	ND	ND	ND	ND
Toxaphene	ND	ND	ND	ND	ND

Variable	3C	3E	3G	3H	4A
			Site Numbers		
Matrix	Liver	Liver	Liver	Liver	Liver
Collection Date	07/21/87	07/21/87	06/24/87	07/21/87	06/23/87
Percent Moisture	79.5	75.5	75.0	74.0	75.0
p,p'-DDD	0.01	ND	0.01	ND	ND
p,p'-DDE	0.01	0.01	0.01	0.05	0.01
Dieldrin	ND	ND	ND	ND	ND
Oxy-chlordane	ND	ND	ND	0.02	0.02
Toxaphene	ND	ND	ND	ND	ND

Variable	4B	5C	5C	5D	5D
			Site Numbers		
	Liver	Liver	Liver	Liver	Liver
Collection Date	06/22/87	07/21/87	07/21/87	07/21/87	07/21/87
Percent Moisture	80.5	70.0	73.5	76.5	82.5
p,p'-DDD	ND	ND	ND	ND	ND
p,p'-DDE	0.06	0.01	0.01	ND	ND
Dieldrin	ND	ND	ND	ND	ND
Oxy-chlordane	0.02	ND	ND	ND	ND
Toxaphene	ND	ND	ND	ND	ND

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Table 19. Concentrations of organochlorines in whole fish samples from the San Luis Valley.

Variable	16	26	1B	1B	1B
			Site Numbers		
Species	Brown Trout	Brown Trout	Northern Pike	White Sucker	White Sucker
Collection Date	10/15/87	10/13/87	10/15/87	10/15/87	10/15/87
Number in Sample	2	5	3	4	5
Percent Moisture	74.2	78.0	74.8	74.8	69.4
r-Chlordane	ND	ND	0.01	0.02	0.01
α-Chlordane	ND	ND	0.03	0.06	0.03
p,p'-DDD	ND	ND	0.19	0.30	0.16
p,p'-DDE	0.06	0.02	1.90	2.30	1.20
o,p'-DDD	ND	ND	0.03	0.04	0.02
o,p'-DDE	ND	ND	0.01	0.02	ND
p,p'-DDT	ND	ND	0.05	0.19	0.04
Dieldrin	ND	ND	ND	ND	ND
cis-Nonachlor	ND	ND	0.01	0.03	0.01
t-Nonachlor	ND	ND	0.03	0.06	0.02
Oxychlordane	ND	ND	ND	ND	ND
Toxaphene	ND	ND	ND	ND	ND

Variable	4A	16	17	26	27
			Site Numbers		
Species	White Sucker	White Sucker	White Sucker	White Sucker	White Sucker
Collection Date	06/22/87	10/15/87	10/15/87	10/13/87	10/13/87
Number in Sample	1	5	5	5	5
Percent Moisture	73.2	76.4	74.6	76.4	77.8
r-Chlordane	ND	ND	ND	ND	ND
α-Chlordane	ND	ND	0.01	ND	ND
p,p'-DDD	ND	ND	0.01	ND	0.02
p,p'-DDE	0.50	0.02	0.06	0.01	0.09
o,p'-DDD	ND	ND	0.01	ND	ND
o,p'-DDE	ND	ND	ND	ND	ND
p,p'-DDT	ND	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND	ND
cis-Nonachlor	ND	ND	ND	ND	ND
t-Nonachlor	ND	ND	0.01	ND	ND
Oxychlordane	ND	ND	ND	ND	ND
Toxaphene	1.30	ND	ND	ND	ND

Table 19. (continued)

Variable	1B	2A	2A	5A	5B
	Site Numbers				
Species	Common Carp	Common Carp	Common Carp	Common Carp	Common Carp
Collection Date	10/15/87	08/15/86	08/15/86	06/22/87	06/22/87
Number in Sample	4	1	5	5	5
Percent Moisture	74.4	76.8	80.8	77.8	76.4
r-Chlordane	0.01	ND	ND	ND	ND
α-Chlordane	0.01	ND	ND	ND	ND
p,p'-DDD	0.06	ND	ND	ND	ND
p,p'-DDE	0.53	0.01	0.01	ND	ND
o,p'-DDD	ND	ND	ND	ND	ND
o,p'-DDE	ND	ND	ND	ND	ND
p,p'-DDT	ND	ND	ND	ND	ND
Dieldrin	ND	0.01	ND	ND	ND
cis-Nonachlor	ND	ND	ND	ND	ND
t-Nonachlor	0.01	ND	ND	ND	ND
Oxychlordane	ND	ND	ND	ND	ND
Toxaphene	ND	ND	ND	ND	ND

Variable	4B	17	18	27	16
	Site Numbers				
Species	Fathead Minnow	Fathead Minnow	Fathead Minnow	Fathead Minnow	Rio Grande Chub
Collection Date	06/22/87	10/15/87	10/15/87	10/13/87	10/15/87
Number in Sample	--	11	12	30	25
Percent Moisture	83.0	78.8	75.0	76.6	74.0
r-Chlordane	ND	ND	ND	ND	ND
α-Chlordane	ND	ND	ND	ND	ND
p,p'-DDD	ND	ND	0.02	0.02	ND
p,p'-DDE	0.01	0.04	0.08	0.07	0.02
o,p'-DDD	ND	ND	ND	ND	ND
o,p'-DDE	ND	ND	ND	ND	ND
p,p'-DDT	ND	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND	ND
cis-Nonachlor	ND	ND	ND	ND	ND
t-Nonachlor	ND	ND	ND	ND	ND
Oxychlordane	ND	ND	ND	ND	ND
Toxaphene	ND	ND	ND	ND	ND

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Table 20. Concentrations of DDE in aquatic invertebrates, aquatic plant, plankton, and sediment samples from the San Luis Valley.

Variable	Site Numbers 26	18	1A	1A	1B
Sample Type	Invert.	Invert.	Pondweed	Pondweed	Cinqufoil
Collection Date	10/13/87	10/15/87	08/15/86	08/15/86	10/15/87
Percent Moisture	98.2	90.5	89.8	90.4	89.5
p,p'-DDE	ND	0.01	ND	ND	ND

Variable	Site Numbers 2A	4C	16	18	18
Sample Type	Pondweed	Algae	plant	plant	Watercres
Collection Date	08/15/86	06/24/87	10/15/87	10/15/87	10/15/87
Percent Moisture	81.4	83.5	91.5	85.5	94.5
p,p'-DDE	ND	ND	ND	ND	ND

Variable	Site Numbers 26	27	4A	4A	4C
Sample Type	plant	Algae	plankton	plankton	plankton
Collection Date	10/13/87	10/13/87	06/24/87	06/24/87	06/24/87
Percent Moisture	95.8	92.8	92.5	94.5	91.5
p,p'-DDE	ND	ND	0.01	ND	ND

Variable	Site Numbers 4D	1A	1A	1B	2A
Sample Type	plankton	sediment	sediment	sediment	sediment
Collection Date	06/24/87	08/15/86	08/15/86	10/15/87	08/15/86
Percent Moisture	94.5	57.4	28.6	41.8	46.6
p,p'-DDE	ND	ND	ND	0.04	ND

Variable	Site Numbers 16	17	18	26	27
Sample Type	sediment	sediment	sediment	sediment	sediment
Collection Date	10/15/87	10/15/87	10/15/87	10/13/87	10/13/87
Percent Moisture	31.2	26.6	26.0	19.0	30.0
p,p'-DDE	ND	ND	ND	ND	ND

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